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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 99. 6455

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See half-page Advertisement, last and next week.

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6094
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See Full Page Advt., page 70, March 8.

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See Advertisement page 39, March 15. 2402

Taylor & Challen Presses.
6196
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See Full Page Advertisement March 8th.

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See our Advertisement in last week's issue, page 20.
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See half-page Advertisement page 99, March 22.

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For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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TENDERS.

COUNTY BOROUGH OF BARROW-IN-FURNESS.

The Corporation are prepared to receive

Tenders for the Painting of the BASCULE OPENING BRIDGE over the Walney Channel, which is 1123 ft. between abutments.

Specifications, Forms of Tender, and any other particulars required may be obtained upon application at the Office of the Borough Engineer and Surveyor, Town Hall, Barrow-in-Furness, and Tenders, endorsed "Painting, Walney Bridge," must be delivered at my Office at or before Twelve o'clock noon on the 17th April, 1918.

The lowest or any Tender not necessarily accepted.

By Order,
L. HEWLETT,
Town Clerk. K 715

SOUTH STAFFORDSHIRE WATER WORKS COMPANY.

The Chairman and Directors invite

Tenders from Engineering Firms for a PLANT capable of pumping 1 to 1 million gallons per 24 hours from a well into a reservoir under a total head of 627 ft., which includes friction.

The site is situate in the Birmingham district.

Forms of Tender, copies of conditions and specification may be obtained from the undersigned.

The lowest or any Tender will not necessarily be accepted.

FRED. J. DIXON, M.Inst.C.E.,
Engineer,
Paradise Street,
Birmingham. K 866

PRELIMINARY ANNOUNCEMENT.

By Order of the Proprietor, who is retiring from business, Messrs. FULLER, HORSEY, SONS & CASSELL are instructed to invite

Tenders for the Purchase, in one lot, as a GOING CONCERN, of the old-established
FREEHOLD SHIPBUILDING & ENGINEERING WORKS,
at Canning Town of
A. W. ROBERTSON & CO.

The works, which have the extensive frontage to Bow Creek of 480 ft., contain an area of about two acres. The buildings are conveniently arranged for economical construction and are equipped with modern Shipbuilding and Engineering Plant.

The whole of the fixed plant, machinery and fixtures, as also the
GOODWILL OF THE BUSINESS,
with patterns and drawings and work in progress, will be included in the sale. The purchaser will have an option of acquiring the loose plant, tools, stock and stores at a valuation. He will be entitled to the beneficial interest in the running contracts, but required to give an indemnity in respect thereof.

Tenders, which must be on the form attached to the particulars, must be delivered by Twelve noon on MONDAY, APRIL 22nd, at the Office of the AUCTIONEERS, 133, High Holborn, W.C. 1.

The Works may be viewed by orders only, to be obtained of Messrs. FORBES & SON, Solicitors, 19, Mark Lane, E.C., and of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. K 893

IMPORTANT TO ENGINEERS.

By Order of ENGINEERING IMPROVEMENT COMPANY, LTD., owing to Machinery having been requisitioned by the Government, and the Company's employees called up for active service.

Messrs. FULLER, HORSEY, SONS & CASSELL, are instructed to invite

Tenders for the Purchase of 800 GROSS OF
"PERFLOC" PATENT LOCK NUTS,
namely:—300 gross of 1 in. and 500 gross of ¾ in. made to Whitworth's commercial standard gauge and finished bright. Samples may be seen at the Auctioneers' Offices, and Tenders may be for one, or any number of gross.

Tenders are also invited for the Purchase of the BENEFICIAL INTEREST IN AN AGREEMENT, dated 3rd July, 1917, with Vickers, Ltd., whereby for a period of five years they have the right of manufacturing "Perfloc" Lock Nuts on payment of Royalties. The purchaser would be entitled to these Royalties as and from the date of completion.

Tenders, which must be in the form contained in the Particulars of Sale, should be delivered not later than Twelve noon on MONDAY, APRIL 15th, at the Offices of Messrs. FULLER, HORSEY & CO., Mechanical Auctioneers and Valuers, 133, High Holborn, W.C. 1. K 904

APPOINTMENTS OPEN.

Specification and Schedule CLERK, experienced in mechanical engineering work, REQUIRED in aeroplane factory, London, N.W. No one will be engaged who is on Government work or living more than 10 miles away. State age and salary required, to BOX 257, SELLS LTD., 168, Fleet Street, E.C. 4. K 857

CITY OF HULL EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.

ASSISTANT LECTURER IN ELECTRICAL ENGINEERING.

Wanted, Immediately, for Day and Evening Departments, an ASSISTANT LECTURER, attached to the Engineering Department. Good theoretical and practical training, including some works experience, essential. Some teaching experience desirable. Salary, £175 to £350, by £7 10s. annually, plus 5s. per hour for all Evening Classes.

Further information and Forms of Application may be obtained from the undersigned, to whom applications should be sent immediately.

J. T. RILEY, D.Sc.,
Education Offices, Director of Education.
Albion Street, Hull,
23rd March, 1918. K 854

LONDON COUNTY COUNCIL.

APPOINTMENT OF OPERATION SUPERINTENDENT IN TRAMWAYS DEPARTMENT.

Applications are Invited for the POSITION of OPERATION SUPERINTENDENT in the Traffic Branch at a salary varying from £600 to £800, according to qualifications.

Age not to exceed 50 years. Applications must be on the official form, which specifies the conditions upon which the appointment will be held and the principal duties of the position. The form may be obtained from the Clerk of the Council, County Hall, Spring Gardens, S.W. 1, and must be received at the County Hall, not later than 1 p.m. on 15th April, 1918. An addressed foolscap envelope, bearing 1d. stamp, must be sent with the request for the form of application. K 871

JAMES BIRD,
Clerk of the London County Council.

Costs Clerk, Leeds district, experienced in Locomotive Engineering; thoroughly acquainted with preparation of estimates, also operation of workmen's bonuses, calculation of piecework prices, &c. Capable of taking charge of the department. State age, qualifications and previous engagements. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting this Journal and K 873.

Wanted, Metallurgical CHEMISTS, to take charge of shift on 7-ton Electric (Héroult) Furnace; must have first-class experience with Carbon and Alloy Steels, also laboratory practice. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4948. K 856

Chemist Wanted, to Take Charge of Laboratory and Heat-Treatment Plant, principally on carbon determinations and analysis of oils; used to microscopic work on steel. Only one chemist employed. Good opening for a suitable young man. No person already employed on Government work will be engaged. Write fully.—Address, K 885, Offices of ENGINEERING.

Wanted, Steel Works Chemist for steel foundry with electric furnace. No one at present on Government work will be engaged.—Apply at your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4973. K 864

Responsible Deputy to Works Manager WANTED, at once, for large Engineering Firm. Must have had good experience in well-organized works, comprising engine shops, foundries and boiler shops, and in consequence must be able to assist in improving and maintaining works organization for systematic production. Age 30—36 years; salary £350—£500 per annum, according to qualifications.—Address, K 767, Offices of ENGINEERING.

Firm of Shipbuilders and Engineers can OFFER POSITION of General Manager to an Experienced Engineer, having previously held a similar appointment. Good prospects and the opportunity of taking financial interest if desired.—Address, in strict confidence, stating age, experience and salary required, K 897, Offices of ENGINEERING.

A Firm of Controlled Engi- NEERS, with works in the Midlands and London office, REQUIRE the SERVICES of a Live REPRESENTATIVE, who can influence orders for Steam Specialities. Applicants who have first-class connection. Remuneration by salary and commission.—Address, in first instance, K 798, Offices of ENGINEERING. Nobody already engaged on Government work will be engaged.

Wanted, for Engineer's Works, 30 miles north of London (Controlled Firm) MAN to take charge of Cost and Wages Section. Fully qualified chartered accountant preferred, if possible with experience of Engineering Costs. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, stating salary required and mentioning No. A 4956. K 859

Wanted, by a Firm of Public Works Contractors on Government work, CHIEF MECHANICAL ENGINEER. Must have had experience in similar position previously with firm of repute, must have experience of Excavating Machines and Contractors' Plant generally.—Address, with references and state salary required, to K 831, Offices of ENGINEERING.

Librarian Required, by Large Manufacturing Concern in the Midlands. Applicants must have first-class general education, and be capable of intelligent listing, cataloguing and précis writing from all kinds of commercial and technical periodicals. Ladies or discharged soldiers eligible for the appointment. No applications will be considered which do not give full details of career and state salary required. No one already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4966. K 855

Departmental Engineer WANTED, under Chief Engineer, with special knowledge of Blast Furnace Plant and Locomotives and Locomotive Cranes, by a large firm in the North-East of England. No person already on Government work will be engaged.—Apply, stating age, experience, salary looked for, and with copies of not more than three recent testimonials, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4924. K 806

Assistant Blast Furnace MANAGER WANTED, by a Firm on the North-East Coast. Must have had a scientific training, and technical experience desirable. No person already on Government work will be engaged.—Applications, stating age, experience and salary required, together with copies of recent testimonials, to be made to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4925. K 807

Assistant Chemist, Ineligible for Military service, WANTED for large Engineering works in Newcastle-on-Tyne district, one accustomed to analyses of iron and steel or brass and other non-ferrous alloys. No person already on Government work will be engaged. State age, qualifications and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4856. K 689

Wanted, Junior Chemist, experienced in high-class Steel Melting, for small Electric Steel Furnace.—Applicants must state age, experience and wages required, and apply to their nearest EMPLOYMENT EXCHANGE, quoting No. A 4915. No person already on Government work will be engaged. K 815

Firm of Brassfounders Re- QUIRE experienced TRAVELLER. Good prospects and permanency offered to capable person.—Address, K 901, Offices of ENGINEERING.

Draughtsman Required, with good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4894. K 808

Required at Once the Services of One or Two Good JIG and TOOL DESIGNERS, for large Engineering Works, Manchester District. Good prospects and permanency for the right men. No one already on Government work will be engaged.—State age, experience and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4953. K 856

Wanted, Sheerness District, good Civil Engineering DRAUGHTSMAN, experienced in surveying and general building construction. Ineligible for military service.—Apply by letter, stating age, salary required, full particulars of experience and enclosing copy of recent testimonials, to BOX 1096, WILLING'S, 125, Strand, London, W.C. 2. K 843

Civil Engineering Draughts- MAN REQUIRED, for Government work in Chatham district; should be thoroughly conversant with design of structural steelwork, calculations, &c. Ineligible for military service.—Write, stating age, particulars of experience, salary required and enclosing recent testimonials to BOX 1165, WILLINGS, 125, Strand, W.C. 2. K 844

Draughtsmen, Good Mechani- CAL, WANTED for
(a) Jigs and Tools—Section Leader.
(b) Electrical Machines—Senior and Junior Men.
(c) Control Gear—Senior and Junior Men.
Apply, stating qualifications, age, salary required, and earliest date can commence, to nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 4884. K 775

Several Good Engineering DRAUGHTSMEN REQUIRED by large Controlled Firm in Tyne district, manufacturing aircraft. Experience of aeronautical work desirable but not essential. No one already on Government work will be engaged. Good remuneration offered to competent men.—Write, stating age, experience and qualifications, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 773.

First-class Draughtsmen with good general experience WANTED by large Controlled Firm in South Yorkshire.—Address, giving full particulars of experience, and salary required (inclusive of War Bonus), J 348, Offices of ENGINEERING J 348

Draughtsman (Electrical), WANTED, for the Midlands. Preference given to men with experience in the design of D.C. and A.C. machines or transformers.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 4895. Nobody engaged on Government work will be engaged. K 740

Wanted, Experienced Jig AND TOOL DESIGNERS for large Electrical Works in the Midlands. Knowledge of Press Tools an advantage. Good salary and permanency to really capable men.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 4906. Nobody already engaged on Government work will be engaged. K 739

Draughtsmen (Jig and Tool) WANTED for high-class Aero Engine Repetition Work. Must have good machine shop and some drawing experience. Good salary and overtime pay for keen, practical and intelligent men. No juniors need apply. Persons already employed on Government work will not be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning No. A 4882. K 736

Civil Engineering Draughts- MAN WANTED, experienced in steel work, construction, and ferro-concrete work. Must be ineligible for general military service.—Write, stating age, experience, salary required, and enclosing copies of recent testimonials, to BOX 1135, WILLING'S, 125, Strand, London, W.C. 2. K 759

Engineers, Designers and DRAUGHTSMEN, with previous experience of design of ferro-concrete structures, REQUIRED by L. G. MOUCHEL & PARTNERS, LTD., 36, Victoria Street, S.W. 1.—Apply by letter, stating age, experience, and salary required. K 796

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Draughtsmen.—A Controlled Establishment in the West Riding of Yorkshire, engaged on important high priority work, REQUIRES the SERVICES of a competent MAN, with first-class experience in General Engineering work; also experienced MAN for medium size machine tool work. A LADY TRACER is also required. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. K 809

Draughtsman, having 3 to 4 years' Mechanical experience, REQUIRED by the Research Department of a large manufacturing firm. No man on Government work or resident more than ten miles away will be engaged.—Write, BOX 1174, WILLINGS, 125, Strand, W.C. 2. K 808

Draughtsmen.—Applications REQUESTED for good, experienced Mechanical Draughtsmen. Those with Crane work experience preferred.—State age, salary, experience and when at liberty to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4428. No person already on Government work will be engaged. K 807

Machine Tool Draughtsman WANTED (Manchester district) for electric driving of machine tools, especially reversing motor drives for planers. Electrical knowledge not necessary. State age, experience, and salary required. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4963. K 805

Engineering Draughtsman WANTED. Must have experience of general lay-out arrangements. No person already engaged on Government work will be engaged. Write, stating age, experience, salary required and when disengaged.—Apply, BOX 825, FROST SMITH AND CO., 66, Finsbury Pavement, E.C. 2. K 894

Wanted, by a Large London Aircraft Engineering Works, a number of good Mechanical DRAUGHTSMEN, men with previous aeronautical experience preferred. Write, stating age, experience and salary required. No one will be engaged who resides more than 10 miles away or who is on Government work.—Write, BOX 263, SELLS, Ltd., 168, Fleet St., E.C. 4. K 892

Wanted at Once Experienced Constructional Steelwork DRAUGHTSMEN. Only those not already on Government work and residing within ten miles radius need apply.—Write, stating salary required, previous experience and when can commence.—Address, K 889, Offices of ENGINEERING.

Wanted, Draughtsmen, for Drawing Electrical Apparatus in a Government Department at Portsmouth. Applicants to have at least two years' experience in a commercial drawing office. Wages 67s. 6d. (inclusive) per week of 42 hours, plus overtime.—Replies to BOX 1167, WILLINGS, 125, Strand, London, W.C. 2. K 883

Draughtsman Wanted, for Controlled firm of Structural Engineers, accustomed to design and detailing Steel Frame Buildings, &c. Must be a capable man. No one on Government work or resident more than 10 miles away will be employed.—Address, stating full particulars, K 895, Offices of ENGINEERING.

Draughtsman Required, for Controlled Blast Furnaces and Rolling Mills on the North-East Coast. Men already on Government work need not apply.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, quoting No. A 4844. K 684

Wanted, Draughtsman, with first-class shop experience in the manufacture of Compressed Air Rock Drills. A good salary will be paid to a first-class man. No one at present on Government work will be employed.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 800.

Draughtsman Wanted at Once, to take charge small Works, Drawing Office, Shell Forge (Yorkshire). Must be good Mechanical Engineer, preferably experience jigs, tools and hydraulic plant. No person already engaged on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, stating No. A 4902. K 811

Wanted, an Experienced MECHANIC, as Foreman over Fitting, Machine and Tool Room. Must be accustomed to designing tools and jigs. Micrometer accuracy necessary. One accustomed to internal combustion engine building preferred. Good wages paid to a suitable man with ability for organising work and control of men and boys in the department.—Apply through nearest EMPLOYMENT EXCHANGE, giving full particulars of experience, mentioning this Journal and K 776.

Assistant Foremen (Several) REQUIRED at Once, for Machine Shops in large Engineering Establishment in the Midlands. Good openings for high-class men. No one already on Government work will be engaged.—Apply, stating age, experience and salary required, to the nearest EMPLOYMENT EXCHANGE, mentioning ENGINEERING and K 693.

THE INSTITUTE OF METALS.

(*Concluded from page* 307.)

On the members re-assembling on Thursday evening, the 14th inst., the Secretary announced that the British Foundrymen's Association would hold a meeting in Birmingham on the 23rd, when three papers on melting furnaces would be read and that the members of the Institute of Metals were invited to attend.

An Investigation on Unsound Castings of Admiralty Bronze (88 : 10 : 2); Its Cause and Remedy.

The first paper taken was one having the above title, by Professor Carpenter and Miss C. F. Elam, which we give on page 351 of the present issue. It gave the results of a very complete set of experiments carried out to determine the most favourable casting temperatures and to ascertain the causes which made for unsoundness. The nature of the copper used in the alloy appeared to have little or no influence on the final results; the blowholes were formed by the liberation, on cooling, of gases dissolved in the alloy, but it did not seem likely that they were formed by the liberation of oxygen, as all the oxygen present in the metal was in the form of oxides of zinc, tin or copper, the first two of which were very stable compounds and not at all likely to decompose when once formed. The analysis of the gas obtained by heating pure copper very much resembled that of the gas obtained from a copper-tin alloy, this suggesting that the gases which caused unsoundness in the alloy were actually in the copper itself. The volumes of these gases were also about the same. The most suitable practical way of avoiding porous castings would appear to be to determine the temperature of the alloy so as to insure it being poured within the range 1,270 deg. to 1,150 deg. C.

Professor T. Turner, who took the chair during the reading and discussion of the paper, said that this was the first time in the history of the Institute that a contribution had been made to the proceedings by a lady, and considering the character of the work carried out and the way in which it had been presented, every congratulation was due to Miss Elam.

Mr. J. Dewrance regretted that the value of the contribution would be interfered with by the shortness of paper which would prevent its being distributed, as it should be, to all manufacturers, for it was of the utmost importance to the founder to know where he had to look for the enemy. There had been in the past a tendency to regard the subject in a different light from that suggested by the authors, and the simple language they had used coupled with the way in which they had presented the matter increased the value of their contribution. In regard to temperature measurements, they should remember that Professor Carpenter had a penchant for the pyrometer, which might not be the case with others. But there was no doubt that the results of the authors could not have been presented without the use of a pyrometer, and he (the speaker) hoped that its use would increase; unfortunately there was at present no pyrometer which could be put in the hands of a metal founder. It would be found that whilst Professor Carpenter was suspicious of the accuracy with which a practical founder could ascertain the correct casting temperature, the latter could evince suspicion at what Professor Carpenter could ascertain with his instrument. The frequent use of the pyrometer in foundry experiments for checking purposes was of very great advantage. One effect of the paper would be to show that pouring should be carried out within a certain range of temperature. The paper was an excellent record of the authors' present knowledge in the matter and he expressed the hope that it formed a forecast of the knowledge they were going to further obtain. If from the authors' further work some material could be obtained for putting in the metal to liberate the gas and to enable it to be poured within a greater range of temperature, the members could be even more grateful to the authors than they were to-day.

Commander Jenkin, who followed, said he had read the paper with the greatest interest, for it dealt with a standard alloy which was greatly used by the Air Board, and his intention was to have the paper issued immediately and in large numbers with a view to showing how sound castings of Admiralty bronze could be obtained. He asked the authors to take in hand also the closely allied metal, phosphor-bronze. At the present time great difficulty was experienced owing to the unsoundness of phosphor-bronze castings, and he instanced those used for making the valve seats in aeroplane engines where the lack of soundness in the valve seats led to leakages which might have disastrous consequences.

Mr. M. Thornton Murray congratulated the authors for having put forward a paper of real theoretical and practical value. He agreed with the authors in that, so far, no complete scientific explanation of the unsoundness liable to occur in Admiralty bronze could be put forward. Their statement to the effect that the actual casting operation, provided the temperature could be controlled, was the deciding factor in providing sound castings was, he thought, in view of the comparatively restricted field of the research a somewhat daring statement. But perhaps he differed from the authors in the use of the term "soundness"; since, however, he had been able to see the specimens of castings the authors exhibited at the meeting, he knew the way in which the authors used the term. He admitted that the temperature of pouring was very important, but other factors had to be also considered before castings could be guaranteed good. This particular alloy was susceptible of catching all the ills that alloys were heir to, shrinkage cavities occurred frequently, unless great care was taken in feeding complicated castings. Segregation was also likely to occur. He would have liked to have had physical tests of the authors' castings. He was not entirely persuaded that porosity was due invariably to gas bubbles; hydraulic tests would also have been of great value. He (the speaker) had experienced great difficulty in measuring the temperature of pots of molten Admiralty metal; they had not found suitable protectors. Radiation pyrometers generally gave erroneous readings owing to the zinc fume. That the materials used in the alloy—particularly the copper—made little difference in regard to blowholes, as the authors stated, was interesting, but he had met cases where certain brands of copper had given consistently higher physical tests. The figures which the authors gave as to the composition of the gases was of great interest; to have identified these as furnace gases was no small achievement, but he could not quite account for the high percentage given of hydrogen.

Professor C. A. Edwards said that the authors had clearly indicated that the metal had to be cast within a proper range of temperature, but the difficulty of suggesting a way in which the temperature should be regulated was not yet overcome, and he thought that developments could be looked forward to in regard to the importance which attached to the pouring temperatures. The trouble was due to the fact that foundrymen dealt with small masses of metal, melted in small crucibles, and difficulties surrounded the use of the pyrometer. The crucibles had to be carried over long distances for pouring. The disadvantages that resulted therefrom might be surmounted by having an electric resistance wound round the crucible, the whole being sunk in a carriage which could be wheeled through the foundry, a loose wire connection being provided; the resistance could thereby be regulated and the temperature in the crucible maintained constant. He did not understand why so many people were using the alloy 88 : 10 : 2, and he asked what were its advantages; other alloys could be resorted to which were easier to cast and were quite as good.

Dr. Hatfield referred to Mr. Dewrance's statement that some material should be looked for to liberate the gas, and the authors had also shown the effects due to the gas in solution. He (the speaker) was interested mostly with ferrous metallurgy, and his own experience in that line might perhaps be found useful. If they took blown-steel and sound steel, and abstracted the gases therefrom, it would be found that the gases were similar in both, but blown-steel had less gas than sound steel. The solution of the difficulty might be found in adding some proportion of a compound which would increase the power of the metal to hold the gases. In steel, silicon was added to free the steel as much as possible from dissolved oxides. The authors would perhaps find a solution on the same lines. He would like to have complete detailed analyses of the alloys the authors had dealt with; but was afraid the non-ferrous people were not so careful with their analyses as had to be the case with the ferrous metals.

Mr. F. Johnson, with reference to the authors' statement to the effect that an idea was prevalent that oxygen gas played a considerable part in causing unsoundness, said they were right, for that idea was prevalent among practical men, and those practical men looked for guidance. He also agreed with them in stating that provided the metal was allowed to cool in the crucible, however much it might have been overheated, it was obtained free from blowholes. He asked what they implied when they said that the nature of the copper had little or only a minor influence, for he understood that chemically pure copper always behaved in the same way. Sieverts was mentioned by the authors as stating that carbon monoxide was insoluble in copper; he (the speaker) did not agree with this and thought that the carbon monoxide was soluble. They had referred to a black substance which had deposited in their apparatus for collecting gas, and he asked whether arsenic might not be responsible for this. Further, one of the densities they quoted, for Mersey copper cast in sand at a pouring temperature of 1,137 deg. was given as 9; he would like to have an explanation as to this latter figure. The authors had also stated that zinc lessened the solubility of sulphur dioxide and hydrogen sulphide in the alloy, but they gave no evidence of this. In one of the tables giving the composition of the gases, the carbon dioxide exceeded the carbon monoxide, whilst in another table the carbon dioxide was the lesser figure; he asked whether a transposition of the figures might have taken place. The authors had stated that a gas of approximately the same composition was found in sound and unsound castings and in chill castings, adding that there was not a sufficient difference in the volume of gas obtained from unsound and sound castings to account for the presence of blowholes in the one and their absence from the other. In this connection, Mr. Johnson added, Dr. Hatfield had pointed out that there was more gas in sound than in unsound steel; it had also been shown that there was twice the amount in sound as compared with unsound steel. But there was danger in applying the analogy. Here Mr. Johnson showed some of his own photographs of bronze castings, pointing out that they contained cuprous oxide, and added that the authors appeared not to have taken into consideration the reaction between the oxides in the metal and soluble gas.

Dr. Rosenhain, who followed, said this research, which he was glad had been published, was a typical example of the work now being carried out by ladies; others were working in the same field, but their work could not for the present be made public. He would have liked the paper to include the results of mechanical tests made on actual castings. With regard to temperature control, he agreed with Dr. Edwards' remarks to the effect that there were a large number of small pots to deal with, which made for a change in temperature. The remedy to this was to melt in larger furnaces as was now becoming the practice. He (Dr. Rosenhain) found that Dr. Edwards' suggestion for keeping the metal hot in the crucible was difficult of realisation, since no resistance could withstand the high temperature of about 1,200 deg. and an atmosphere of hydrogen would be fatal to it. The loose wire would also be cumbersome. He also suggested the use with thermo-couples of iron sheets coated with lime and a binding material such as silicate of soda, or that of a graphite tube with which oxidation could also be avoided, or again a shield of carborundum. He also advocated the use of an optical pyrometer. The authors' explanation of the occurrence when the metal was poured too hot he regarded with scepticism, and asked for further data on the blue constituent the authors had referred to.

Mr. A. Cleghorn added his testimony to the value of pyrometry in the brass foundry. The method

of casting metals from crucibles was one in which the temperature could not well be controlled, and he melted all his in furnaces having each a capacity of 3 cwt., in which the temperature could be controlled accurately. He found the men could become expert in using pyrometer readings. The pouring temperature should be as low as possible; this insured better and sounder castings, the physical characteristics of which were improved.

Mr. H. H. A. Greer expressed the opinion that as the fluxes used had a great deal to do in the matter, experiments should be carried out in order to arrive at the most appropriate one. Some people advocated the addition of phosphorus whilst others were against it, and it was difficult to ascertain who were right and who were wrong on this point.

Professor G. B. Brook asked for further explanations in regard to the non-separation of the gases from the metal, and to the difference of only 2 deg. in two temperatures the authors had quoted (1,137 deg. and 1,135 deg. C.). In Sheffield, he added, they had found difficulties in measuring temperatures until they used the Whipple pyrometer which enabled them to make cupro-nickel satisfactorily, and this he thought would be found useful also in the case of Admiralty bronze. He also asked where the sulphur constituent in the author's records came from and whether their metals were melted in a coke fire.

Professor T. Turner emphasised the care which should surround the preparation of specimens to raise the visibility of blowholes. The authors had rightly pointed out, he added—referring to the specimens exhibited—that when the ingot cast was sawn through there were less holes visible to the eye than were present originally. The same could be said in some instances when the section had been polished. There were at least five kinds of porosity, including pinholes the cause of which was obscure, and the cure for one kind was not good for another. The question of the gases would have to be reinvestigated; the authors had shown how complex that question was. But from a practical point of view, their paper was an admirable one; it was the best paper he had seen on the subject, and he warmly congratulated the authors for having brought it forward.

In the course of her reply to the discussion, and with reference first to the advisability of increasing the safe temperature range, Miss C. F. Elam said there were difficulties in the way which would be comparable to those which surrounded the taking of temperatures. She had tried the addition of phosphorus and pouring at 1,400 deg. C., but the castings were still unsound, which showed that the phosphorus addition was not advantageous. She thought the pores formed were not caused by shrinkage. The making of physical tests did not come within the range of the investigations. The authors wanted to clear up the reason for the presence of blowholes and the mechanical point of view did not come in. She used a silica protector in the thermo-couple for taking the temperature, but it lagged and broke up; it would perhaps have been better had it been coated. The actual temperature was not measured, only that of the outside skin which was a good deal lower than the temperature of the metal. By "nature of copper" she meant the different brands of copper, Rio Tinto, cathode copper, &c., and the general results were the same whatever the copper used. She thought that zinc must lower the solubility of the gases; it interfered with these gases, sulphur dioxide and others. In regard to pouring, the equilibrium of the gases must be altered by a sudden drop in temperature. She had been worried by the oxides referred to in the paper, but she had no doubt that they were oxides and she did not know what else they could be. There was sulphur in the electrolytic copper they used, quite a distinct deposit of this had been found. She would reply more fully, she added, to the various points raised in a written contribution to the proceedings.

On Lead, Tin, Antimony Alloys.

The next paper on the list was the one having the above title, by Dr. O. W. Ellis. In his absence, it was taken as read. We reprinted it in full on page 298 of our issue of March 15.

On the Annealing of Aluminium.

This paper dealing with the annealing of aluminium, by Mr. R. J. Anderson, Cleveland, Ohio, U.S.A., was contributed at the last moment.

Mr. D. Hanson and Dr. Gwyer both queried the author's analyses, the silicon content especially, which in one specimen was stated to be as low as 0·06 per cent.; they also queried his scleroscope hardness conditions and his statements as to the effect of work on the grain rise.

After the passing of a vote of thanks to the Chemical Society for the loan of their rooms, Professor Carpenter announced that the May lecture would be delivered at the Institution of Civil Engineers on May 2, by the Hon. Sir Charles Parsons, on the subject of "The Formation of Diamond," a subject on which Sir Charles had been working for nearly thirty years. The President hoped there would be a good attendance of members.

THE ARROWROCK DAM, IDAHO, U.S.A.

In the issue of ENGINEERING of June 29 last,* we gave an illustrated description of the Arrowrock Dam, constructed across the Boisé River, near Boisé, Idaho, this being one of the many important works carried out in recent years in the United States in connection with irrigation undertakings. As explained in our former notice, this dam—the highest yet built—is a Portland cement concrete structure, having a maximum height of 348 ft. and it provides a water storage for the irrigation of 240,000 acres. An account of the construction will be found in the article to which we have already referred, and our present object is to deal with a supplementary work connected with the dam which was only referred to incidentally in our former notice.

As then stated, there are in the Upper Boisé River basin extensive pine forests, and the timber from these can only be transported through the mountainous country by means of "logging" the stream, that is to say, by floating the logs down the river. But the construction of the dam, of course, interfered with the ordinary process, and means had to be devised by which logs floated down into the reservoir could be conveyed past the dam into the river below.

The importance of this work will be understood when we state that it is estimated that there exists 3,000,000,000 ft. board-measure of logs in the forests tributary to the Boisé River and at the proposed rate of cutting of this timber the log conveyer must have a capacity of 60,000,000 ft. board-measure in a period of 75 days each year when the reservoir is full or the water surface is not lower than 40 ft. below the spillway crest. The logs to be dealt with run as large as 6 ft. in diameter, with a maximum length of 60 ft.

We give, on pages 332 and 333, illustrations which will explain the arrangements adopted. Fig. 1, on page 332, is a general view of the dam with the spillway seen on the left, while the log conveyer is shown running down in a straight line on the extreme right, the position being clearly indicated on the plan Fig. 2 on the same page. The appliances include an elevator for raising the logs from the reservoir to the top of the chute, and the chute itself with its feed rollers and chain conveyer. The chief details are shown in the illustrations on page 333. Referring to the sections at E E and G G on that page, it will be seen that the logs are removed from the reservoir by a cable lift, which deposits them on a concrete deck at the top of the dam. From this they are transferred singly by a loading arrangement on to a series of spiked rollers, power driven, which convey them across the top of the dam and deliver them on to a bull chain provided with spurs which prevent the logs from sliding. By this chain the logs are carried forward at a rate of 85 ft. per minute down the gradient shown by the longitudinal section of the chute given on page 333, this chain chute having a length of 390 ft. Finally, the logs are delivered by the chain chute into a gravity chute 245 ft. in length, down which they pass into the river. The total drop from the top of the dam to the river is 250 ft. The arrangement of cable lift provided at the top of the chute is designed to handle all logs up to 32 ft. long. Logs of greater length are taken direct from the reservoir, end on, to the live rollers.

The machinery is all operated by electric power derived from the power station situated some miles below the dam. The apparatus was designed for a maximum hoist of the logs of about 40 ft. vertically at a speed of 150 ft. per minute. The mechanical devices were adapted from similar installations employed in the lumber regions of the Pacific Coast for a lower lift of logs. The entire installation is of a heavy and rugged construction to withstand rough usage. The total cost of the conveyor and appurtenances was 54,200 dols.

As stated in our former notice all the work in connection with the Arrowrock Dam was carried out under the direction of Mr. F. E. Weymouth, supervising engineer for the United States Reclamation Service, Mr. Charles E. Paul being in direct charge as construction engineer, and Mr. James Munn as superintendent of construction. The whole undertaking has been a most successful one.

* See ENGINEERING, vol. ciii, pages 616 and 618.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Continued from page* 322.)

OWING to the unavoidable absence of the Right Hon. the Earl of Durham, President, from the meeting of Thursday morning, the 21st inst., the chair was taken by Sir William E. Smith, one of the Vice-Presidents.

Problems of the Future in the Design and Construction of Merchant Ships.

The first paper taken was the one having the above title, by Mr. W. S. Abell; it was read in abstract by the author, who remarked that he had been very pleased to read Mr. Anderson's paper which was taken on the preceding day and was one of the greatest importance. We reproduce Mr. Abell's paper in full on page 352.

It was taken for discussion in conjunction with the next paper on the list, entitled

Some Notes on the Importance of Research in Marine Engineering,

by Mr. A. E. Seaton, in whose absence it was read in abstract by the Secretary. We reproduce it also on page 354.

The discussion was opened by Sir Philip Watts, who found that Mr. Abell's paper was an interesting and an excellent attempt to stimulate research. He agreed with him, among other points, that large-scale experiments should be carried out, during which the performance of the ships should be recorded and correlated with the results of tank experiments. He also called attention to the fact that several allied institutions owned research committees; he thought the Institution of Naval Architects should not allow itself to remain behind-hand in this respect. He further agreed that the stability of ships at sea was of paramount importance and Mr. Abell's suggestions in this respect were of great value, as also were those he put forward with reference to the stiffness of structures. The investigation in detail of the processes of manufacture was most desirable, and since power processes were cheaper than manual labour, the applications of mechanical power should be greatly extended in the construction of ships.

Mr. L. Peskett, who followed, said Mr. Abell provided in his paper some good advice in regard to future problems in design and construction of merchant ships. The question of the particular type of ship that would ultimately be of the greatest service to the country should be fully discussed by shipowners, and their recommendations carefully considered. The necessity of building 5,000 to 10,000 deadweight cargo ships is fully recognised, but bearing in mind our losses in ships, the post-war repatriation of troops, and the necessity of maintaining our passenger carrying trade, some consideration should also be given to the building of intermediate steamers, to carry passengers with cargo. These ships need not be delayed by the fitting of equipment for passengers at the present time. As soon as such a vessel was at the stage suitable for cargo,

she could go to sea, and the passenger accommodation could be finished at a convenient time. At the present time the building of ships that could at the end of the war be converted into passenger vessels was forbidden, and steamship owners who by their own enterprise had brought to a high standard a class of vessel that had won for this country the supremacy of the sea should be given a reasonable opportunity to maintain it.

In his paper, Mr. Abell drew attention to the necessity of having further information from the actual results given by ships which had made several voyages, the lines of which had been developed from tank experiments. Much information could be gathered from the shipowners, and an analysis of the factors which determined the value of a ship as a commercial asset taken from the logs for several voyages would be of immense value for guidance in design, of much more value than the data obtained at trial trips on the measured mile. In regard to stability, Mr. Abell was incorrect in stating that estimates of the arm of righting couple and the angle of vanishing stability were seldom made. Most builders furnished a metacentric diagram of stability curves, and supplied also diagrams showing stability under various conditions of loading. What was wanted was intelligent stevedores who knew where and how to stow cargo to suit the eccentricities of individual ships. In regard to subdivisions, shipowners generally thought that the enforcement of new rules should be deferred until investigation had been made of the types of vessels sunk during the war. The new Board of Trade rules on subdivision were not international, and their enforcement might retard our progress. Most of the ships torpedoed had gone down by the head or by the stern; this would seem to indicate higher bulkheads, or provision of means for flooding an end to bring the ship near an even keel. When an intermediate or mixed type of ship was sub-divided according to the Bulkhead Committee's curves, and considering the boats carried under davits, the length of hatchways was limited. A 580-ft. ship, having water-tube boilers, with oil fuel, carrying 520 cabin passengers and 1,700 third-class, and also a deadweight cargo of about 11,000 tons, would be a valuable asset at the close of the war. Less boats under davits, but flotation for all in the shape of easily handled rafts, would admit of the increase of the hatchways and would increase the speed of loading and unloading.

In regard to the saving of material, ships built to the rules of the classification societies were difficult to improve upon. The cellular double bottom appeared to be the only part where reductions might be made, but its inaccessibility and the frequent filling and emptying of tanks rendered it more liable to corrosion than the upper structure. Other considerations made it imperative that this part of the vessel should be of greater strength than that demanded by the results of calculation which, even with a given factor of safety, did not always provide for unknown stresses.

Professor W. E. Dalby said that the two papers which had just been read emphasised the fact that research was now in the air. Many members could say how difficult it had been for the scientific man very often to come in, the idea which very generally prevailed being that the practical man in a large way of business had all the knowledge. The war, however, disastrous as it was, had changed matters in that respect. But this did not apply to the Institution of Naval Architects. As an instance of this, Professor Dalby gave a few personal experiences of his and stated that 20 years ago he had carried out researches in the balancing of engines and had found a sympathetic listener in Sir Alfred Yarrow. Sir Alfred gave Professor Dalby information on a torpedo boat, and in a very short time the latter solved the balancing problem. On the advice of Sir Alfred, Professor Dalby communicated the work to the Institution of Naval Architects, and he took that opportunity for stating that he had always found in the Institution an atmosphere in which a scientific man could grow.

The fact should not be lost sight of that a large amount of research work was done in works and factories for solving particular problems. Unfortunately, that research work remained in the works and factories instead of being brought to light and co-ordinated. If that were done, he thought we would all be astonished at its scope. Everybody knew the miracle of Newton; he produced miraculous co-ordination. Sir Isaac himself had not produced the experiments upon which the famous "Principia" were founded; he was a co-ordinator who co-ordinated the results obtained by others. It was co-ordinators that we lacked; we had tables upon tables, but what was wanted was general principles. No committee ever produced an idea; it was the private person who had the ideas, and more often than not he had to fight the committee to get his idea considered. He supposed it was necessary to have committees, but it was necessary also that the man carrying out research work should be surrounded with the sympathy of practical men. And when talking of research there frequently was a different meaning attached to the term, it might mean to one man an improvement in some mechanism or process, which would enable him to undersell his competitor. At Cambridge he had heard a man say that research was a thing of no use to anybody. It should be remembered that the man who did a piece of work which had no apparent relation to engineering, or indeed to anything, should be encouraged to go his own gait. He instanced, in this connection, the work carried out 30 years ago by Professor Guthrie, who shut himself up in his laboratory at Kensington where he busied himself in dissolving salt in water and investigating the freezing point of the solution. That was the beginning of a research which proved most useful in metallurgy, in the iron and carbon alloy. With regard to Mr. Abell's statement to the effect that in the large majority of merchant vessels the wave-making resistance was only some 20 per cent. of the total resistance, that being the amount of resistance due to eddies in the tank, he would say that the frictional resistance of the skin of the ship accounted for a much bigger proportion. Yet all the practical results were made on planks of small area, the length not exceeding 50 ft. In that, there was a whole practice built on a slender basis. Professor Dalby said he had suggested at a meeting of the Institution three or four years ago the use of a photographic recording dynamometer for observing the variations in skin resistance of two vessels. It showed how necessary it was to develop that kind of research on a broad foundation, when there was a starting point available. Mr. Seaton's contribution was an interesting one, but the crux of the whole matter of developing invention was capital, and it was just here that State intervention in the direction of providing capital could most profitably be made. We hoped much from the Committee of the Privy Council for Scientific and Industrial Research, and, so long as various institutions, like that of the Naval Architects, were represented and the committee would be guided by the advice given to them, something would come from their work. We looked forward to the work of that committee, and the two papers just read were important in that they called attention forcibly to scientific research that had no immediate prospect of profitable return.

Sir William Rowan Thomson, dealing with Mr. Peskett's remarks with regard to the obtaining of data from trial trips, said there was difficulty in getting reliable data from shipowners, or in obtaining their logs to deduce therefrom reliable information, and that difficulty was due to the very large amount of clerical work involved. Mr. Peskett had also referred to the necessity of building liner types of ships; he must have overlooked the fact that the type in question was now being built, and it could be adapted to the carrying of passengers. Mr. Abell's remarks concerning the collaboration in design on the part of the owners was the difficulty. There was the variety in ship and machinery to be considered and if collaboration could be carried out it was not only desirable, but absolutely necessary if bulk production in connection with ships and machinery was the end in view. Collaboration would involve the same design and also agreement among the parties concerned. While they might differ individually as to detail, the particular item might be quite good and sufficient for its purpose. Bulk production was necessary for speedy and cheap production. It was only by repetition work that one could arrive at the maximum range of output.

He, the speaker, was glad to see in print Mr. Abell's remark to the effect that there was need for the study of labour processes as applied to the question of shipbuilding. In this respect, the paper summed up the great difficulty of labour and showed that increased output could only be brought about by the joint effort of employer and employed and increase of remuneration for both parties. This had been one of the greatest stumbling blocks to the introduction of the system of payment by results. He did not think research would become a practical reality in the case of individual firms, because the firms had their hands full with their daily task and research work added to that would form a serious item in the cost. Research work could only be carried out by institutions supported by the industry at large.

Mr. E. L. Orde expressed his personal thanks to the authors for their papers, and found that there was a most important necessity for research work. The subjects dealt with, he thought, could be divided into two parts, there being in the first place the plea made for research and, secondly, the directions in which it should be carried out. They all agreed that research was necessary, and it was more necessary at the present day than it ever had been. The directions pointed out in the papers were most comprehensive. In the remarks made by the former speakers the point had been raised as to how research could be carried out so as to benefit the industry generally, and this required fuller attention. If research was to benefit industry as a whole it must be carried out on a large scale. Reference had been made to experiment with full size steamers to determine the skin friction of cargo steamers. That, however, was beyond the reach of any single firm. Individual firms did not impart the knowledge they gained from their own researches, and it was necessary therefore that research work should be in the charge of the Institution as a whole and should be confined in its operation to the trades with which it was most intimately connected. He assumed that Mr. Seaton would desire that research in marine engineering, to which he had referred, should be carried out by marine engineers only. But research work was liable to lead into by-paths, and the results arrived at were often both intangible and late in arriving. It should be conducted on the strictest possible lines and the results made known rapidly.

Mr. D. B. Morison said that Mr. Seaton's opening statement to the effect that scientific research was necessary for marine engineering was a general proposition which would be accepted without a dissentient voice might be true, but on the other hand there was no engineer so conservative as the marine engineer, and in that he was no doubt right because when a mistake was made it could not easily be corrected, and the mistake might have grave results. The North-East Coast Institution of Engineers and Shipbuilders had made a departure in that respect, and would investigate apparatus approved by the Council and report thereon for the benefit of its members and engineers. He also referred to the report of an investigation which had already been made, involving over 250 tests, this report giving instructive data. A further research was being made into apparatus used on shipboard and the tests had demonstrated a saving of half the quantity of brass, and much weight, labour and money. What killed industrial researchers was the "wet blanket" thrown on them by powerful interests and the apathy shown as to the results obtained. In this respect, we did not always compare favourably with other countries, and he stated as an example that before the war he went to the Admiralty in Berlin there to discuss novel apparatus for which it was desired to claim protection in Germany. All the German officers he met at the interview spoke English perfectly, they examined the matter and called in a captain who gave an excellent report on the plant he (the speaker) was interested in, and also gave comparative results of the apparatus already in use. It was decided by the Berlin authorities that his system should be tried on one side of a battleship and the German one on the other side. Mr. Morison said he would win in

THE ARROWROCK DAM, NEAR BOISÉ, IDAHO, U.S.A.

(*For Description, see Page* 330.)

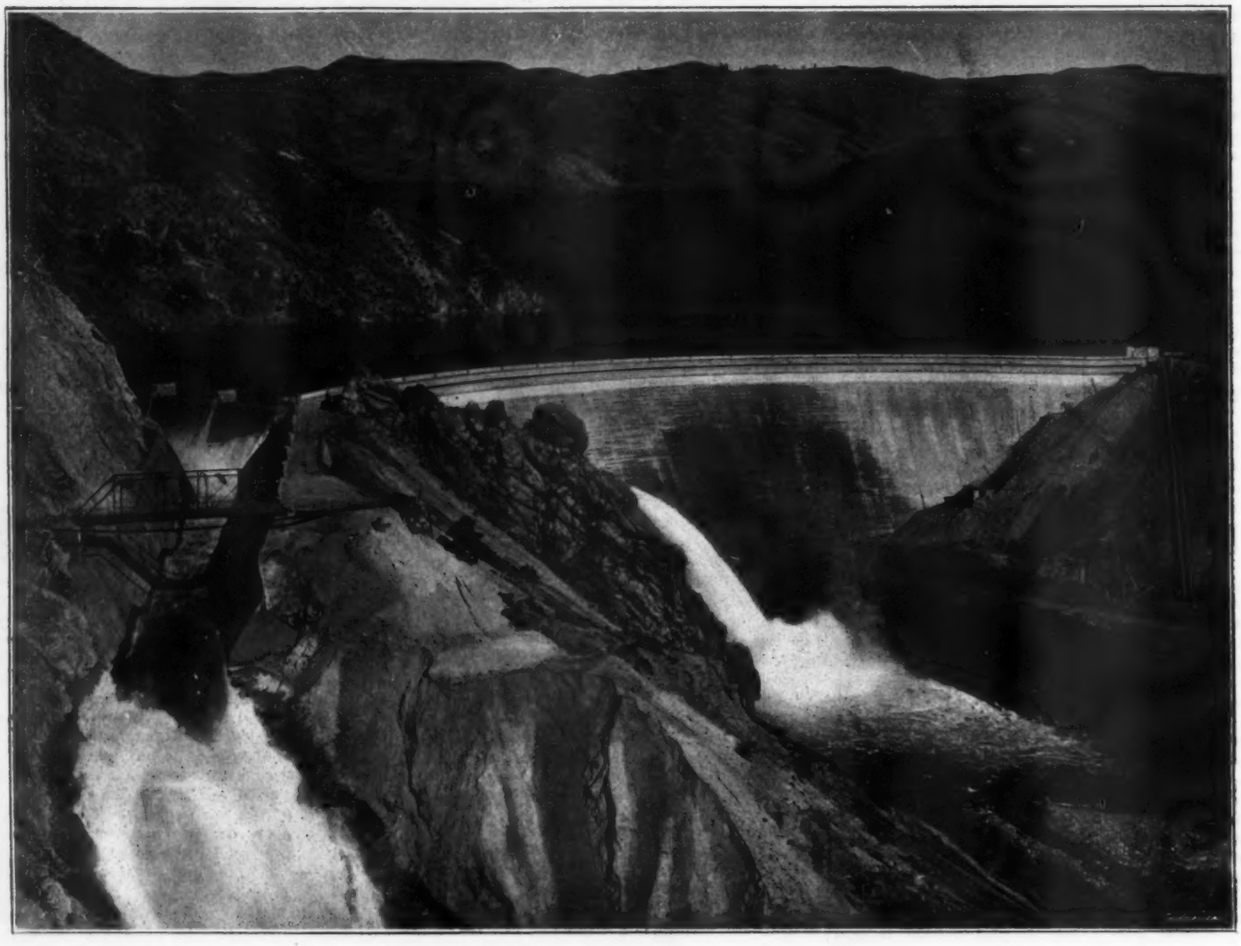
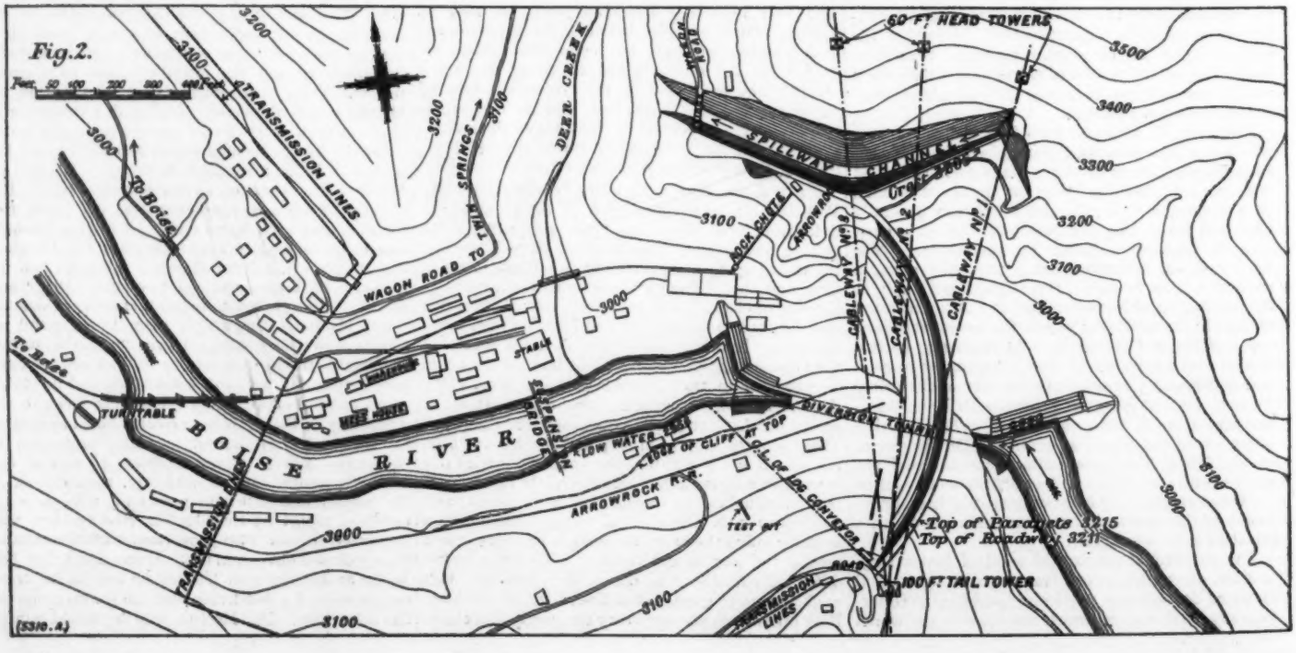
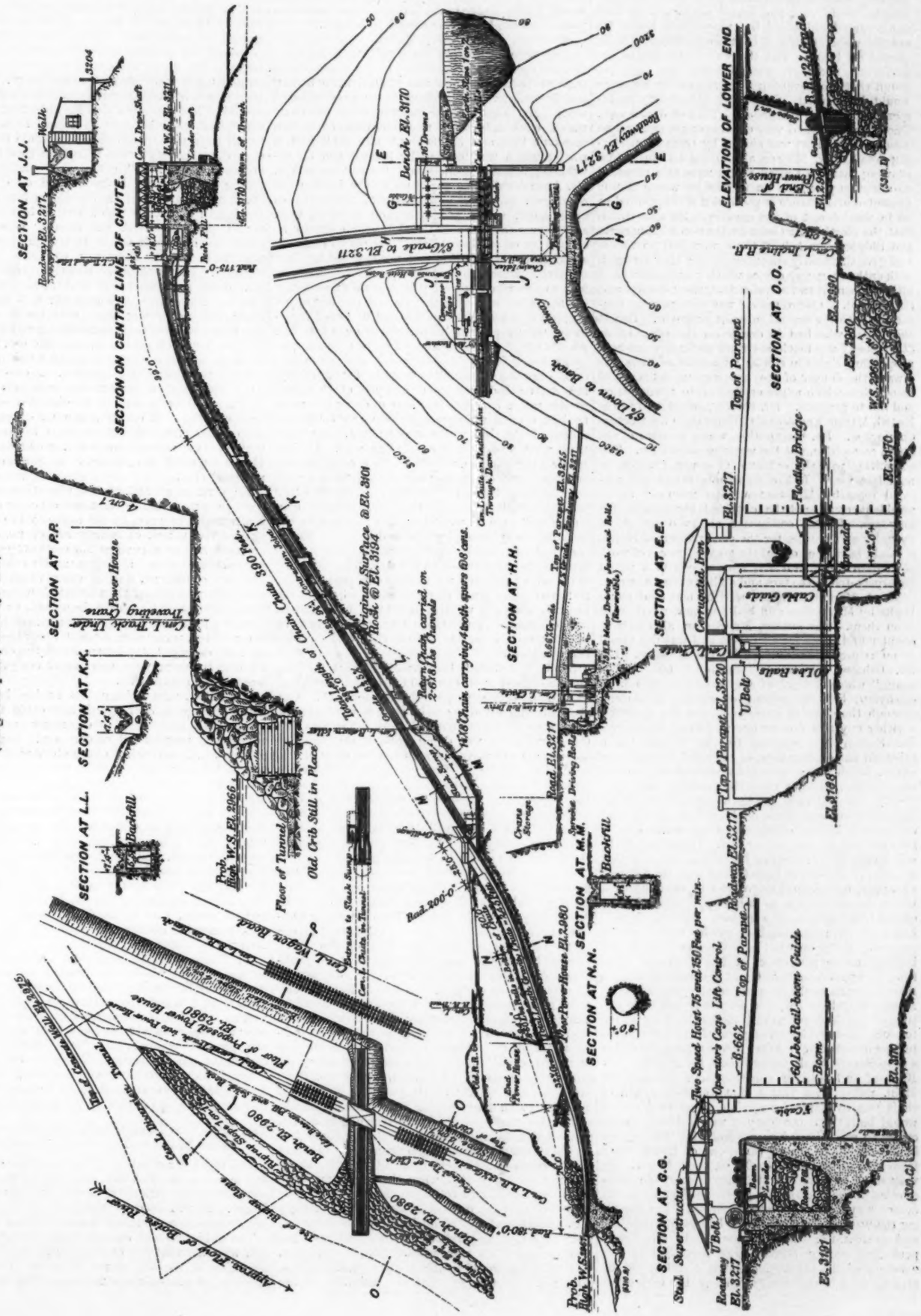


FIG. 1.



THE ARROWROCK DAM, IDAHO, U.S.A.; DETAILS OF TIMBER CONVEYOR AND CHUTE.

(For Description, see Page 330.)



the trial, and the Berlin authorities wanted to know why he would win, and added that when the time came each detail would be exhaustively tested for efficiency and endurance both before and after being placed on board. But the war broke out in the meantime, and there was no doubt that they had found that the advantages he claimed for his plant would be secured. Germany's persistency in research had to be recognised. That of Japan also. Those countries had very capable engineers, and no time and no effort was spared by them in mastering detail. Mr. Morison also added an illustration showing that the United States were also prepared to adopt any scheme no matter by whom it was presented and whence it proceeded if it appeared to be in the interest of the country. He also stated that the North-East Coast Institution of Engineers and Shipbuilders helped those who had no means and gave them early encouragement; they accepted with enthusiasm any device which promised to be of ultimate benefit to the individual, the industry, and the district. Co-ordination was necessary in connection with the several schemes proposed. He felt that those who had to decide on the adoption or otherwise of any machine should preferably not hold proprietary rights in similar apparatus as there was always the danger of the unconscious influence of association which might easily lead to retrogression and not to progress. Mr. Seaton had referred to the British Marine Engineering Design and Construction Committee. He, the speaker, was a member of the grand committee, not the working committee. The committee was the outcome of a paper which he read last year. It had 24 members and was presided over by Mr. Seaton than whom a better president could not be obtained throughout the kingdom. If this committee achieved its object by unifying the rules for the construction of boilers it would have done one of the greatest pieces of work of modern times, and if it were successful it would be largely due to the tact and ability of its chairman.

Mr. J. Hamilton Gibson said he had read many books by Mr. Seaton and had always derived profit from them. The author, Mr. Seaton, always gave chapter and verse for all points and was not afraid to make propositions which invited criticism. He, Mr. Gibson, translated "research" by "search again," which did not of a necessity imply a fresh discovery, but the passing of known phenomena through the sieve of experience and the detection whether any new fact or law was likely to emerge. Mr. Seaton had referred to the success which attended the examination of the spoil banks of old mines, which was a most interesting point, and he, the speaker, thought that the carrying out of research with the spoil banks which existed in the vicinity of our coal mines might well repay the work of research by the obtaining of by-products such, for example, as shale oil for fuel. One result of the war might be to force our hands somewhat in that direction. He had no fault to find with Mr. Seaton's appendix, but would like to refer to the suggestion which was there made as to the application of roller or ball bearings to marine engines. He, the speaker, had little faith in these bearings for use in marine engines. But from what he had seen of the Michell bearing and the persistence in that bearing of the oil film, as applied to thrust and journal bearings, a marine engine could be made to run without wear. Actual propulsive effect of propellers was now possible and could compare with the results given by the torsion meter. The accuracy of the latter required further investigation. When it was remembered that a propeller shaft only twisted about 1 degree for every 10 ft. of its length, or a quarter inch movement at 12-in. radius, and that a much shorter length of shaft was available for torsior meter purposes, it would be realised how easy it was for considerable errors to creep in. A movement of $\frac{1}{4}$ in., or even less, in which to record variations of horse power from zero up to, say, 30,000 or even 40,000, was very small, and errors would also arise by the introduction of the multiplying gear. In Group 2 of Mr. Seaton's appendix the very important point regarding the water circulation in the boilers was omitted, and consideration should be given to it. The Liverpool Engineering Society was investigating the question of the insulating material and would be glad to work in this connection together with other societies. The two papers which had just been read would arouse suggestions, and the more numerous these were the better one should be pleased.

Mr. G. S. Baker, who followed, said that both papers were intimately connected with research. He, the speaker, was in charge of the experimental tank at Teddington and was pleased when he saw the Institution were willing to support research work. Mr. Abell's paper touched upon the items which most interested research workers in the speaker's line, and Mr. Seaton's also dealt with a matter which was touched by himself and his coworkers, namely, propulsion by screw propellers. Mr. Abell divided his paper under the headings of resistance, power required at sea, resistance of appendages, screw propellers and seaworthiness, and suggested that additional research should be carried out on all the subjects. The more one learnt about these matters the more one saw the need for research. During the last three years there had been four papers read suggesting large-scale experiments in connection with skin friction and resistance, yet nothing had been done so far, and he hoped something would ultimately be, following upon Mr. Abell's paper. The difficulty had been alluded to by Professor Dalby. Only properly carried out full-scale experiments could surmount that difficulty. Mr. Seaton had mentioned analysis of ship trial results, and in his own experience of doing this work he had been handicapped because one could not obtain all the data which were wanted. Few ship trials were conducted in a scientific way. He had read all the papers connected with such trials and had not found one giving sufficient data to render an analysis of the results possible. If, on the other hand, the trials were made properly, one could gain a good deal from them. They were prepared at the tank and always ready to help the designers. Reference had been made to the variations which were periodically made in the ship forms. That could be witnessed at the tank where they saw year by year features coming in and going out later. Some of the features were not wanted, but were, nevertheless, insisted upon. New ship forms should not be adopted merely for the reason that other people adopted them.

Sir William Smith here remarked that the two authors agreed upon one point, namely, that there existed a necessity for further research. This should be impressed upon the persons who gave the funds for carrying out research work. The fact that the Government was doing work in the same line did not absolve private firms from the duty of also conducting research. They were indebted for the tank to Sir Alfred Yarrow, who initiated it, and to the support of various firms. Steps had been taken to conserve any contributions made by firms so as to leave a practically free hand for research work, and money could be more usefully applied in the future than it had been in the past.

Professor Welch said the two papers were a most powerful plea for the carrying out of research work. All the members were certain as to the necessity for it and they all would endorse Mr. Seaton's suggestion that a considerable portion of the grant placed at the disposal of the Committee of the Privy Council by the Government should be made available for the objects indicated by the two papers. The transactions of the Institution of Naval Architects gave many records of researches made by individual members, but many of the more intricate researches were beyond the resources of the individual members, and he hoped that recommendations in regard to these latter researches, put before the Committee of the Privy Council, would bear fruit. Mr. Abell had stated that the outbreak of war had interfered with the carrying out of investigations, and in this connection Professor Welch stated that a kindred association had appointed a committee for the standardisation of shop fittings and to report on the articles which were best suited for standardisation; he hoped that when the report appeared effective and definite action would be taken. The latest holder of the Institution Research Scholarship (Mr. Champness) did intend to carry out investigations abroad on shipbuilding practice, but had since been engaged on war work. He, the speaker, trusted that he would be able to carry out his original intention. He thought that the definition of the function of a ship should read "in similar trades and for similar routes the most successful vessel is that which attains the greatest power of transportation at minimum cost." With this wider definition it would be possbile to get distinct differences between this figure of merit so to speak as between long-distance and short-distance ships, whereas each might be equally successful in several spheres. Mr. Abell had entered a plea for obtaining detailed reports of the experience of vessels at sea which would mean that special observers would have to be carried, as the ship's officers had not time to ensure accurate results. With the ship under control rolling motion could be moderated by change of speed and course, but that would adversely affect the length of voyage which was to be avoided as far as possible. With the steering gear broken down the ship would fall in the trough of the wave, wherefore it was necessary to have adequate stability. In regard to the watertight subdivisions, Mr. Abell mentioned one and two-compartment vessels. These were well-understood terms if the limitations underlying them were borne in mind. The terms were not used by the Bulkhead Committee because it was thought that, in public use, it might be easy to forget what a one-compartment and a two-compartment ship really was. A one-compartment ship had a certain assumed permeability which might or might not be obtained on a particular voyage. If designed as a one-compartment shop under standard conditions, it might well be that on some voyages the vessel would be a $1\frac{1}{8}$ or $1\frac{1}{4}$-compartment ship, in effect a fractional compartment ship.

He took it as Mr. Abell's view that post-war constructions would be dominated so far as bulkheads were concerned, by the necessity of providing against the attack of submarines or mines. For ordinary marine casualties 1.3 compartment ships were better than 1 compartment ships. In ordinary conditions, and in cases where the permeability was greater than assumed in the calculations, where a fire occurred in a hold, or the ship sprang a leak, or a hatchway was stoved in during bad weather, under such circumstances the amount of cargo damaged was lessened and the chances of the ship surviving were increased as compared with a one-compartment ship.

Mr. Millar, who claimed that he had been over half-a-century in a shipyard, and could therefore speak with experience, had, many years ago, advocated longitudinal decks and longitudinal bottoms. He had taken out protection for such a system ten years ago. If there was waste in a ship Mr. Millar contended it was in the double bottom. He had been long enough in the profession to have seen the first application of these bottoms in coastal steamers of 400 to 800 tons. To meet the difficulties which supervened the plates were thickened without success, and the double frame was introduced, which modified but did not cure the trouble. He had five ships at the present time built with longitudinal bottoms, transverse framing and longitudinal decks, and he would be pleased to give to any member desirous of inspecting the system facilities for doing so at Greenock.

Sir William Smith, in moving a vote of thanks to the authors which was heartily responded to, invited further written contributions to the discussion and asked the authors to reply also by writing. He found it somewhat unsatisfactory that the two papers should not have been written until the present, comparatively late, period in the history of the Institution. Many of the matters referred to ought to have been dealt with long ago. To the call for an attempt to do better in future, he thought the two papers were a noble response.

The Effect of Longitudinal Motion of a Ship on its Statical Transverse Stability.

The third paper taken at the meeting of Thursday morning, the 21st inst., was the one having the above title, by Mr. G. S. Baker and Miss E. M. Keary. It was read in abstract by the former. We propose to reproduce it in a later issue.

The discussion was opened by Sir George Greenhill, who said that loss of stability in wave motion, especially at the top of the wave was a familiar point to all boatmen and fishermen, but so far he

had not found in the ordinary treatise any explanation of the baffling phenomenon. He therefore welcomed Mr. Baker's explanations. Guided by Mr. Baker's experiments and by those of others we should find the facts whereon to base a theoretical explanation.

Sir George then referred to the interesting experiments carried out by Colonel Russo, which formed the subject of a contribution to the Institution two years ago. Unfortunately Colonel Russo's boat disappeared from view just when one wanted to study its motion, *i.e.*, when it was beginning to roll over in consequence of the phenomena Mr. Baker had examined. The "Smith" effect in the phenomenon must be very powerful. It had been described by Sir William White and others, but the speaker had not recognised the chairman as the author. The speaker desired to present another point of view due to a virtual and periodic change in density of the water, which produced the same effect which Sir George expressed by the formula

$$\frac{\Delta W}{W} = \pi \frac{H}{L} \times 100 \times \sin n t,$$

adding that he proposed to submit to the secretary later a short geometrical note on the subject. He instanced the case of towing a toy boat on ornamental waters, and it had been to him a great gratification to see it capsize on the top of a wave of its own creation. The length of the tow rope was of great importance, and great care had to be taken when the steamer changed its speed, rounded a corner, or cast off. These questions might engage the attention of younger members of the Institution.

Sir William Smith said it was gratifying to see from Sir George Greenhill's remarks what could be achieved by simple observation. The author's paper was the first paper bearing on this subject. The paper was the first one contributed by a lady read before the Institution. This latter was confronted with much work which was of a nature to be undertaken by ladies.

Mr. G. S. Baker, in the course of a brief reply, said it was difficult to produce a purely scientific paper which would also be popular when read at a desk; a scientific paper had to be read carefully by individual members. He thought it would be found that he had given Sir George Greenhill's formula in another form. No matter how the stream lines were moving, the centrifugal force would effect the gravity, and it might be regarded either as gravity or density; no difference would be made in the ultimate result. He had had experience as a seaman, and knew how a ship had to be towed so as to avoid capsizing.

(To be continued.)

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on Friday, March 8, 1918, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper on "*The Asymmetrical Distribution of Corpuscular Radiation Produced by X-rays*" was read by Mr. E. A. Owen. Of this paper the following is an abstract:—

1. The ratio of emergent to incident corpuscular radiation in the case of the two salts, potassium bromide and silver nitrate, has been investigated, when the exciting X-radiations were the characteristic radiations of copper, bromine, silver and tin.

2. The ratio has the same value whether the salt is in the wet or in the dry state.

3. The value of the ratio was found to be approximately the same for each two of the salts, and is equal to 1.17. This is approximately the same figure as that found by other observers in the case of the metals, gold and silver.

Discussion.—Dr. D. Owen said the experimental results appeared to be conclusive, and the ratio obtained agreed surprisingly well with the values of other observers. It seemed to him that the preponderance of secondary radiation on the emergent side followed from any theory of X-radiation. On the other pulse theory we had, in addition to the electromagnetic forces in the wave front, the momentum of the incident beam, which would tend to assist the emission in the direction of emergence and retard it in the reverse direction. Similar considerations applied to the continuous wave theory, while on the quantum theory the energy was concentrated in blows which fell on very small parts of the atoms, and might have quite sufficient momentum to dislodge electrons. He gave numerical figures to show that if the intensity of the beam was of the order of full sunlight, it would be sufficient to account for the emission of $10^{-15}\beta$ particles per second per square centimetre of the screen.

Dr. H. S. Allen said that if he understood the paper rightly, the result that Mr. Owen had found—viz., that the ratio of emergent to incident corpuscular radiation was the same in the amorphous as in the crystalline state, rendered doubtful the explanation of asymmetry put forward by H. A. Wilson. In his opinion an explanation of a more fundamental character was required than that which attributed the asymmetry of the scattered radiation to the difference between the behaviour of crystalline and amorphous material. In this connection a recent paper by A. H. Compton (Journal of the Washington Academy of Science, January 4, 1918) was of considerable interest. He assumed that the electron was in the form of a spherical shell, each part of which could scatter independently, and might be capable of rotational motion. He showed that it was then possible to explain not only the asymmetry of the scattered rays, but also the diminution of scattering with decrease of wave-length. Since the mass of an electron could not be accounted for on the basis of a uniform distribution of electricity over the surface of a sphere, Mr. Compton suggested that the true shape of the electron might be that of a ring, having an effective radius many times greater than that ordinarily accepted. Mr. Compton's estimate of the radius was 2.5×10^{-10} cm., but if some recent measurements by Sir Ernest Rutherford were used in the calculation, this estimate must be reduced to about one-tenth of the value stated (*Nature*, vol. c, page 510, 1918). If this hypothesis of a ring electron were accepted, the electron might act as a small magnet, as suggested by A. L. Parson, and this explained Forman's effect of magnetisation of iron upon its absorption coefficient.

Mr. T. Smith thought the initial equation with which the paper started was somewhat extraordinary. It was difficult to see what physical considerations gave rise to the factor $\cos \frac{1}{2}\theta$ in the denominator of an equation which he presumed was intended to apply from 0 deg. to 180 deg.

The author, in reply, said that if the asymmetry was to be attributed to the pressure of radiation, one would expect that the value of the ratio obtained for the asymmetry would vary with the intensity of the exciting X-radiation. It had been shown, however, by Philpot that this was not the case, the value of the ratio remaining the same for radiations of the same wave-length whether a beam of X-rays direct from a bulb or a beam of characteristic rays from a metal plate, were employed to excite the corpuscular radiation; the intensity of the radiation would be much greater in the former than in the latter case. The results of the present paper showed that the explanation put forward by Wilson to explain the asymmetry in the case of X-radiation did not appear to be adequate to explain the asymmetry in the case of corpuscular radiation. He agreed with Dr. Allen that an explanation of a more fundamental character was necessary to account for this phenomenon.

A paper on "'*Air Standard*' *Internal-Combustion Engine Cycles and their Efficiencies*," was read by the president, Professor C. H. Lees, D.Sc., F.R.S. Of this paper the following is an abstract:—

It is well known that the efficiency of an air standard internal-combustion engine working through a cycle bounded by two adiabatics, and either two isothermals, two constant volume lines or two constant pressure lines is given by $1 - (1/r)^{\gamma-1}$ where r is the compression ratio and γ is the ratio of the two specific heats of air.

In the present paper it is shown that the efficiency is given by the same expression if the cycle is composed of two adiabatics and two curves $p v^{\frac{a}{a}} = A$, $p v^{\frac{a}{a}} = a$, where a has any positive or negative value and A and a are constants. Since a may be chosen so that any explosion curve may be followed as closely as desired by short lengths of a curves, a cycle can be drawn with the above efficiency and any prescribed explosion curve. The ratio of the efficiency of a cycle with prescribed explosion and exhaust curves to that of the cycle so drawn is shown to be the ratio of the two areas on the indicator diagram. The thermal efficiency of a cycle with prescribed explosion and exhaust curves is therefore readily found.

Discussion.—Dr. D. Owen asked what the ratio of the efficiencies of the actual and theoretical cycles was in practice.

Dr. H. S. Allen asked if it was not possible to generalise the result established in the paper, and to say that the expression for the efficiency held when the explosion curve was represented by $f(p, v) =$ constant, where $f(p, v)$ was any function of p and v, provided the equation for the exhaust curve was suitably chosen.

Professor Lees, in reply, said the ratio of the actual cycle to the other was usually 0.9 to 0.95. Dr. Allen's suggestion was quite correct. He had aimed, however, at expressing the result in a form suitable for graphical calculation.

"REGISTER OF OVERSEAS BUYERS."—The first edition of this register, which measures 10 in. by 7 in. close upon 400 pages, has been compiled with the assistance of Chambers of Commerce and H.M. Consuls abroad, and is issued at the price of £1 1s. net by Messrs. Bemrose and Sons, Limited, London and Derby. Besides containing a list of the principal imports in Allied and Neutral Countries, arranged geographically under the class of goods they import, the volume includes articles on overseas trade written under the authority of Chambers of Commerce abroad. The requirements of the Colonies and Foreign Countries and how to extend trade with them are dealt with thoroughly, as also are the causes which have hitherto impeded British trade development. A large amount of information is also given on the coinage of various countries, lighthouse, quay and other duties, Government officials, Chambers of Commerce, banking facilities, newspapers, local trading conditions, &c., all of which will prove useful for the development of our trade.

REINFORCED-CONCRETE SEA-GOING CARGO STEAMERS.

*On the Design and Construction of Self-propelled Reinforced Concrete Sea-going Cargo Steamers, now building in Great Britain.**

By Mr. T. G. OWENS THURSTON.

WHEN in April, 1914, I had the honour of reading before this Institution a paper on "Some Questions relating to Battle ship Design," I could never have imagined that my next contribution would be on the construction of ferro-concrete ships.

For years past one has heard of the construction of small vessels or barges of ferro-concrete, but these were never of sufficient size or importance to warrant closer investigation, and the whole subject appeared to be one that could safely be ignored so far as ocean-going ships were concerned.

The enormous losses of cargo-carrying ships during the war, coupled with the great scarcity of steel for shipbuilding on account of its diversion to other uses, have made shipbuilders endeavour to find some other material to replace steel for ship construction, even if only as a temporary measure; in this particular direction, shipowners have perhaps been really more progressive in their ideas than the shipbuilders. It was largely owing to shipowning friends of mine, who recognised the disastrous effect which the immense losses of mercantile tonnage would eventually have on the country, that steps were taken which led to the inception of the design and construction of the ships forming the subject of this paper. Without knowing anything as to the merits of ferro-concrete for shipbuilding purposes, they considered that if small craft had already been built with such material it was worth a trial, under present conditions, in larger ones, and after much consideration and investigation of the work previously done in this direction the author finally agreed with them.

The possibility of building wooden ships to make up for the scarcity of steel ships had been carefully considered, but it was found that although the timber supplies in certain countries were adequate for the purpose, a long time must elapse before green timber would be sufficiently seasoned to allow of its efficient use in ships' hulls, although in many cases such timber has been used, and has proved more or less satisfactory for a limited time. In addition to this, the problem of skilled labour would have been accentuated rather than relieved, as it was a practical impossibility to get a sufficient number of men skilled in wooden shipbuilding to allow of construction except on a very moderate scale. These and other considerations led us to abandon the idea of wooden shipbuilding as an efficient substitute under the present urgent circumstances in favour of ferro-concrete, the latter being a material which, if successful, would at once allow a large addition to be made to the present output of cargo-carrying tonnage. Moreover, the system of construction calls for a minimum amount of steel and a minimum amount of skilled labour. Such construction also reduced capital expenditure on yard plant, as it is much less costly than ordinary shipyard plant and requires less skilled attention. Another point in favour of ferro-concrete construction is that, compared with ordinary shipyard labour, there is not so great a variety of trades involved. For example, the same men who, at a later date, are employed on casting the hull, are in the initial stages utilised in casting and laying concrete blocks and in making ferro-concrete piles for the building berths and other necessary preliminary work, for which this material can be used extensively instead of timber or steel, both of which require skilled labour of different trades.

Although the suitability of ferro-concrete under present abnormal conditions and on economical considerations was apparent, its acceptability for ship construction, had to be investigated from the naval architect's point of view. With this object in view, we decided to design a sea-going cargo vessel of reasonably large dimensions to assure ourselves that such a vessel, constructed of ferro-concrete, would satisfy conditions of strength, seaworthiness, deadweight capacity, &c. The difficulties in the preparation of the design proved much greater than was anticipated, for whilst we, as shipbuilders, could prepare and supply the particulars and drawings of the vessel and approximate to the maximum stresses coming on the various members, we had no practical experience of the construction of the ferro-concrete part of the hull, so that it became necessary to work in conjunction with a reliable firm of ferro-concrete engineers, who would carry out this part of the design, basing it on work actually done. This association of shipbuilders and ferro-concrete engineers has proved mutually satisfactory and advantageous, and each party found that it had something to learn from the other with respect to shipbuilding of this type.

It was eventually decided that a self-propelled cargo vessel of about 1,150 tons deadweight was as large as we were justified in commencing as a first venture. It was agreed that the vessel should comply with all the requirements obtaining for steel vessels, and the general scheme was based upon that of a similar ship constructed of steel. The dimensions, for reasons which occurred in preparing the design, differed from those of a steel ship of the same deadweight carrying capacity, especially in length. The dimensions and other particulars finally decided upon were as given on page 337.

* Paper read at the Spring meetings of the fifty-ninth session of the Institution of Naval Architects, March 22, 1918.

REINFORCED-CONCRETE SEA-GOING CARGO STEAMERS.

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, BARROW-IN-FURNESS.

Fig. 1.
LENGTH B.P. 205'0" × 32'0" × 19'6" MLD DEPTH

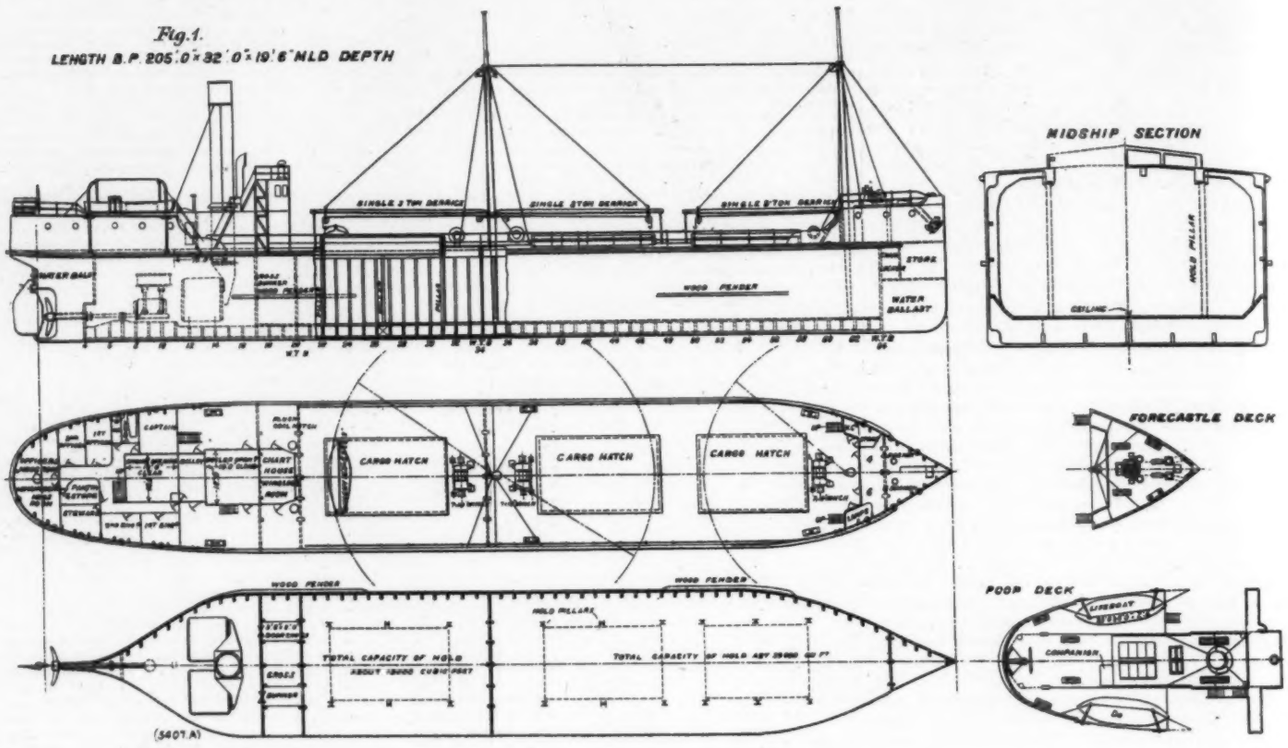
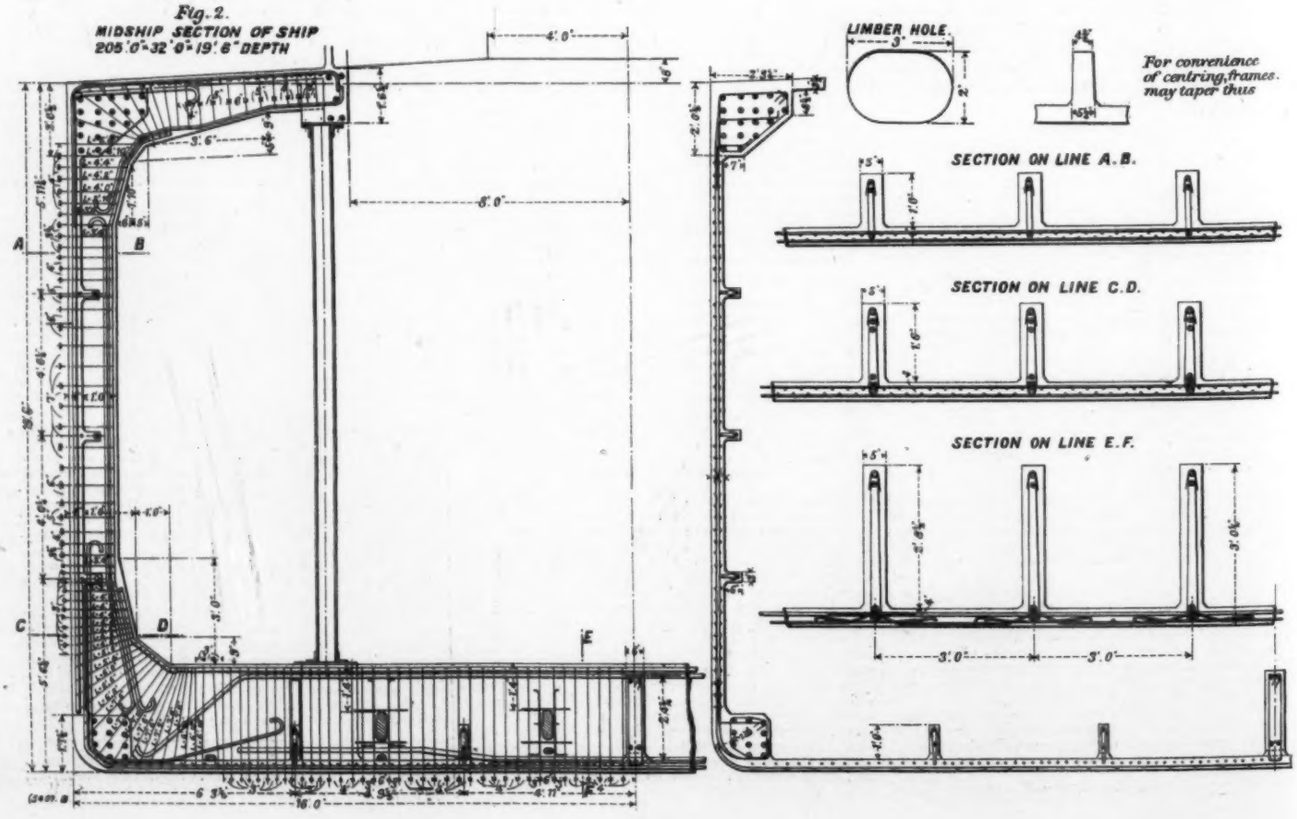
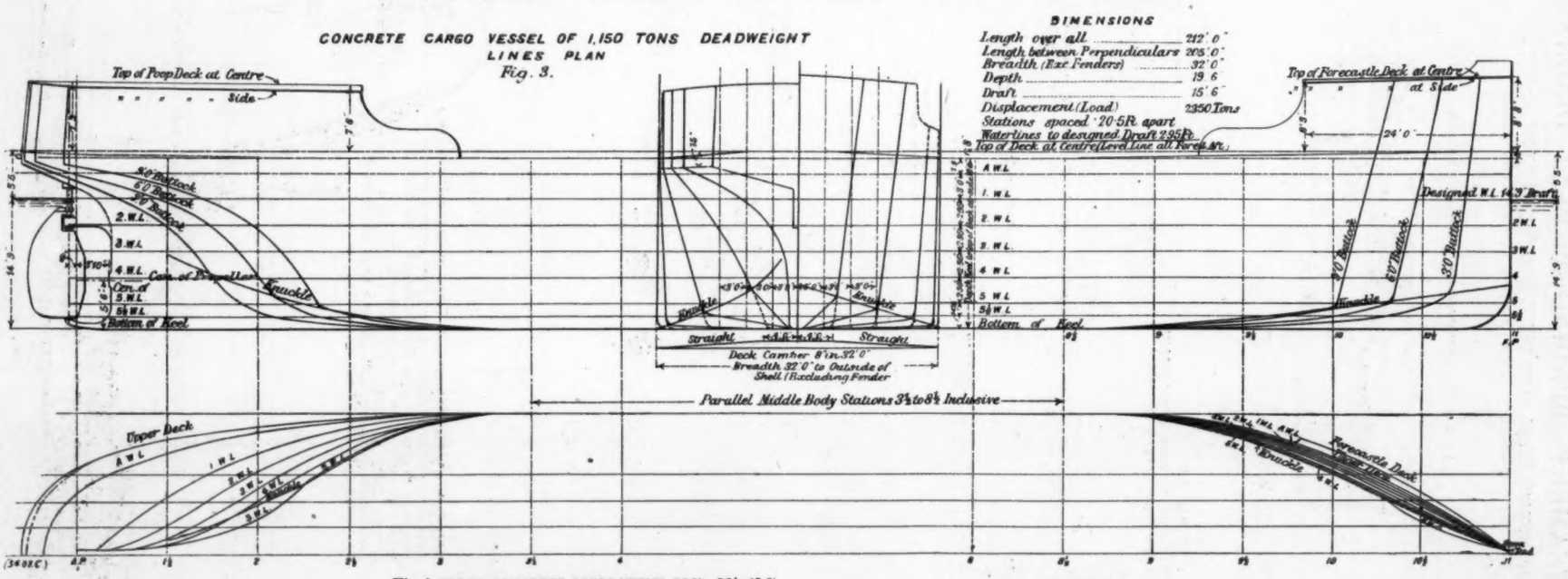


Fig. 2.
MIDSHIP SECTION OF SHIP
205'0" × 32'0" × 19'6" DEPTH



REINFORCED-CONCRETE SEA-GOING CARGO STEAMERS.


CONCRETE CARGO VESSEL OF 1,150 TONS DEADWEIGHT
LINES PLAN
Fig. 3.
DIMENSIONS
Length over all ... 212' 0"
Length between Perpendiculars 205' 0"
Breadth (Ext. Fenders) ... 32' 0"
Depth ... 19' 6"
Draft ... 15' 6"
Displacement (Load) ... 2350 Tons
Stations spaced 20·5R. apart
Waterlines to designed Draft 2·95 Ft.
Top of Deck at Centre (Level line all Forward)
Top of Poop Deck at Centre
Top of Forecastle Deck at Centre
Designed W.L. 14'3" Draft
Parallel Middle Body Stations 3½ to 8½ Inclusive
Deck Camber 8"in 32'0"
Breadth 32'0" to Outside of Shell (Excluding Fender
Upper Deck
Forecastle Deck

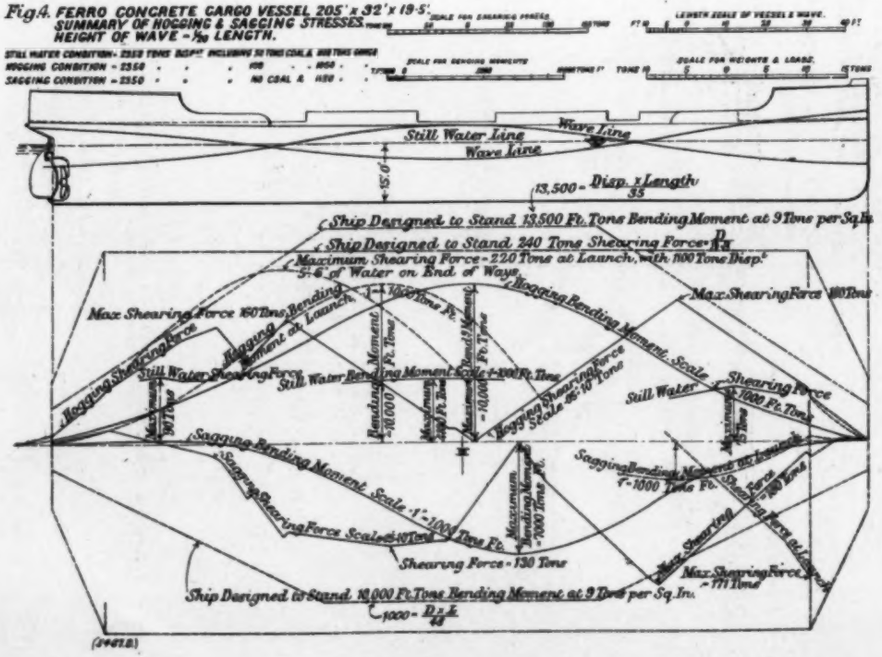


Fig 4. FERRO CONCRETE CARGO VESSEL 205' x 32' x 19·5'.
SUMMARY OF HOGGING & SAGGING STRESSES.
HEIGHT OF WAVE = 1/20 LENGTH.
Still Water Line
Wave Line
Ship Designed to Stand 13,500 Ft. Tons Bending Moment at 9 Tons per Sq. In.
Ship Designed to Stand 240 Tons Shearing Force.
Maximum Shearing Force = 220 Tons at Launch, with 1100 Tons Displ.
Max. Shearing Force 180 Tons
Hogging Bending Moment Scale
Still Water Bending Moment Scale
Still Water Shearing Force
Hogging Shearing Force Scale
Sagging Bending Moment Scale
Sagging Shearing Force Scale
Shearing Force = 130 Tons
Max. Shearing Force = 111 Tons
Ship Designed to Stand 10,000 Ft. Tons Bending Moment at 9 Tons per Sq. In.

Length between perpendiculars	...	...	205 ft.
Breadth moulded	...	...	32 ft.
Depth moulded	...	...	19 ft. 6 in.
Draught, when loaded	...	...	15 ft. 6 in.
I.H.P. (about)	...	...	400
Speed (about)	...	...	7½ knots.

The following drawings indicate the general arrangement and other features of the vessel: Fig. 1, page 336, general arrangement plan; Fig. 2, page 336, midship section; Fig. 3, above, sheer draught or lines plan of the vessel. The various arrangement drawings were prepared and scantlings arranged in accordance with Lloyd's Rules for steel ships. Using these scantlings, a list was made up of the calculated section moduli of the various members. Upon these particulars the engineers prepared constructional sections, on the Hennebique principle of "equivalent strength," which were adopted as a basis for calculation of weights, &c. The design was then carefully reconsidered and calculations made as far as possible for the stresses which the vessel would be subjected to, both longitudinally and transversely, under all reasonable conditions of construction, launching, and service. One of the first things observed in the case of the ferro-concrete hull was that the centre of gravity of the structural material worked out much lower than in the case of a steel hull, the result being a greater metacentric height than was desirable. To minimise this, the original beam of 34 ft. was reduced to 32 ft., and in order to obtain the same hold capacity the depth was increased from the original 17 ft. 6 in. to 19 ft. 6 in., fortunately, from the point of view of longitudinal strength, a modification in the right direction.

Longitudinal Strength.—In calculating longitudinal stresses the vessel was first of all assumed to be in still water with the holds loaded uniformly to the full-load condition, giving a displacement of 2,350 tons. In this condition the maximum bending moment worked out at about 4,100 ft.-tons. For hogging stresses the vessel was taken as being in the same load condition and on the crest of a trochoidal wave of length equal to the length B.P. of the vessel, and height equal to $\frac{\text{length}}{20}$ giving a maximum shearing force of 180 tons and a maximum bending moment of 10,000 ft.-tons. In the sagging condition the vessel was much more severely loaded, three-fifths of the cargo being placed in the middle of the hold space, and one-fifth at each end respectively, resulting in a maximum shearing force of 180 tons and a maximum bending moment of 7,000 ft.-tons.

In the case of launching, the maximum shearing force reached as high as 220 tons, with a maximum bending moment of 10,000 ft.-tons. A generous margin was allowed over these figures, and the vessel was designed to stand the stresses corresponding to the following:—

Hogging moment—
$$\frac{\text{Displacement} \times \text{length}}{35} = 13{,}500 \text{ ft.-tons.}$$

Sagging moment—
$$\frac{\text{Displacement} \times \text{length}}{48} = 10{,}000 \text{ ft.-tons.}$$

Shearing force—
$$\frac{\text{Displacement}}{9.8} = 240 \text{ tons.}$$

REINFORCED-CONCRETE SEA-GOING STEAMERS; BENDING MOMENT DIAGRAMS.

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, BARROW-IN-FURNESS.

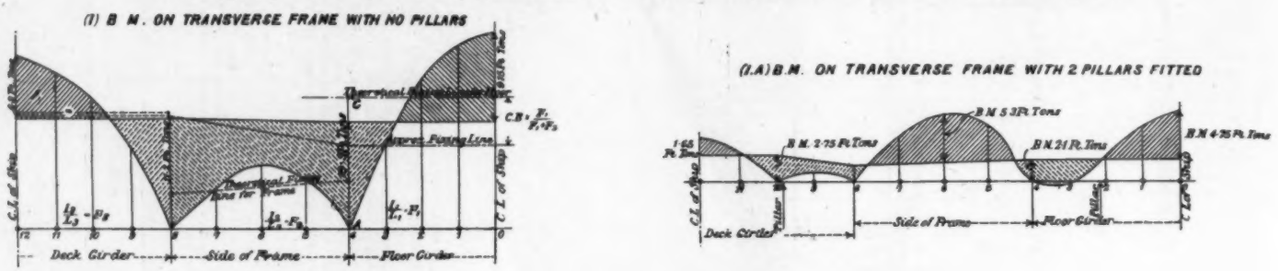
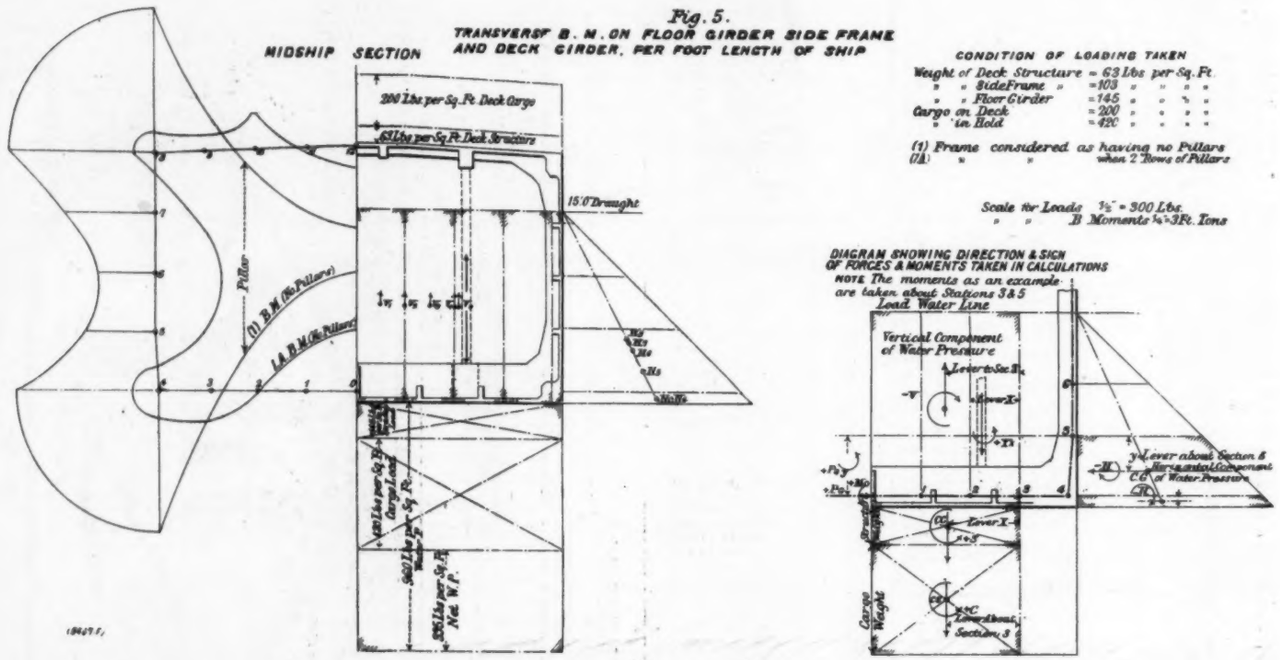

(1) B M. ON TRANSVERSE FRAME WITH NO PILLARS
Deck Girder
Side of Frame
Floor Girder
(1.A) B.M. ON TRANSVERSE FRAME WITH 2 PILLARS FITTED
B.M. 5.3 Ft. Tons
B.M. 2.75 Ft. Tons
B.M. 2.1 Ft. Tons
B.M. 4.25 Ft. Tons
Deck Girder
Side of Frame
Floor Girder

Fig. 5.


TRANSVERSE B. M. ON FLOOR GIRDER SIDE FRAME AND DECK GIRDER, PER FOOT LENGTH OF SHIP
MIDSHIP SECTION
200 Lbs. per Sq. Ft. Deck Cargo
61 Lbs. per Sq. Ft. Deck Structure
15'0" Draught
Pillar
(1) B.M. (No Pillars)
1.A B.M. (2 Pillars)
CONDITION OF LOADING TAKEN
Weight of Deck Structure = 63 Lbs. per Sq. Ft.
" " Side Frame " = 103 " " " "
" " Floor Girder " = 145 " " " "
Cargo on Deck = 200 " " " "
" in Hold = 420 " " " "
(1) Frame considered as having no Pillars
(1A) " " when 2 Rows of Pillars
Scale for Loads ½" = 300 Lbs.
" " B Moments ¼" = 3 Ft. Tons
DIAGRAM SHOWING DIRECTION & SIGN OF FORCES & MOMENTS TAKEN IN CALCULATIONS
NOTE The moments as an example are taken about Stations 3 & 5
Load Water Line
Vertical Component of Water Pressure
Lever X
Lever about Section 5
Horizontal Component C.G. of Water Pressure
Cargo Weight
Lever about Section 3

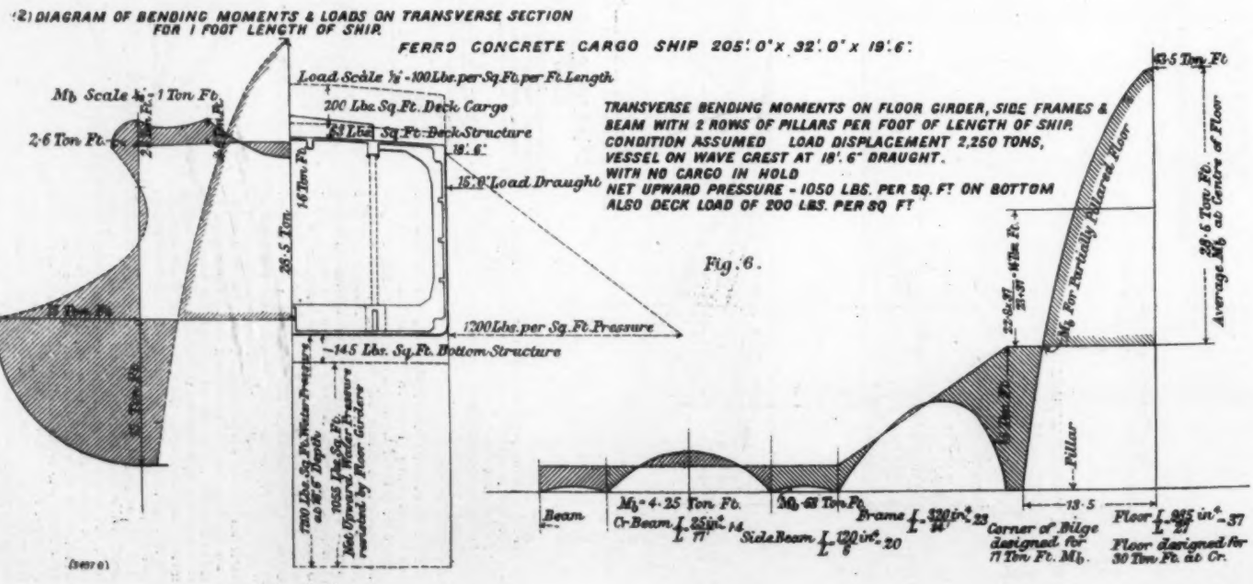

(2) DIAGRAM OF BENDING MOMENTS & LOADS ON TRANSVERSE SECTION FOR 1 FOOT LENGTH OF SHIP.
FERRO CONCRETE CARGO SHIP 205'.0" x 32'.0" x 19'.6"
Mb Scale ½" = 1 Ton Ft.
Load Scale ½" = 100 Lbs. per Sq. Ft. per Ft. Length
200 Lbs. Sq. Ft. Deck Cargo
61 Lbs. Sq. Ft. Deck Structure
18'.6"
15'.0" Load Draught
14.5 Ton Ft.
28.5 Ton
1200 Lbs. per Sq. Ft. Pressure
14.5 Lbs. Sq. Ft. Bottom Structure
1200 Lbs. Sq. Ft. Water Pressure at 15'.0" Depth
1035 Lbs. Sq. Ft. Upward Water Pressure resisted by Floor Girders
TRANSVERSE BENDING MOMENTS ON FLOOR GIRDER, SIDE FRAMES & BEAM WITH 2 ROWS OF PILLARS PER FOOT OF LENGTH OF SHIP.
CONDITION ASSUMED LOAD DISPLACEMENT 2,250 TONS, VESSEL ON WAVE CREST AT 18'.6" DRAUGHT.
WITH NO CARGO IN HOLD
NET UPWARD PRESSURE - 1050 LBS. PER SQ. FT. ON BOTTOM
ALSO DECK LOAD OF 200 LBS. PER SQ. FT.
43.5 Ton Ft
Mb For Partially Filled Floor
Average Mb at Centre of Floor
Pillar
Beam
Mb = 4.25 Ton Ft.
Cr Beam L 25 in.² 14
L 11'
Side Beam L 12.0 in.² 20
L 6'
Frame L 3.20 in.² 23
L 14'
Corner of Bilge designed for 11 Ton Ft. Mb.
Floor L 9.15 in.² 37
L 27'
Floor designed for 30 Ton Ft. at Cr.

Fig. 6.

the structural material being arranged so that the tensile stress on the reinforcement, taking account of a local stresses, never exceeded 9 tons per square inch, and the maximum compressive stress on the concrete 750 lb. per square inch. Fig. 4, page 337, shows the longitudinal bending moment curves of the vessel in the various conditions.

Transverse Strength.—In calculating transverse strength the transverse framing was analyzed in order to ascertain the maximum bending moment to be resisted by the floors, frames, and beams under the various systems of loading to be met with in service.

The conditions assumed, for which calculations were made, are as follows:—

(1) Vessel, without pillars, loaded to deep draught in still water. Cargo load in hold and on deck (see Fig. 5, page 338).

(1*a*) Vessel, with two pillars fitted, one at each side of hatch opening, loaded to deep draught in still water as in condition (1) (see Fig. 5).

(2) Vessel, with two pillars fitted, loaded as in (1) and situated on wave crest, with no cargo on floor girder (see Fig. 6, page 338).

(3) Vessel, with two pillars fitted, loaded and situated in wave hollow with full cargo, load centrally placed below hatches and no deck cargo.

(4) Vessel, with two pillars fitted, in light condition, in dry dock, docked on centre keel.

The calculations were investigated on the "principle of least work," taking the reinforced framing as monolithic. In the moment as calculated there has been taken into account the stresses in the framing where only a partial support is received from the pillaring through the medium of longitudinal girders spanning between the transverse frames. The scantlings of the framing have been proportioned to the more severe conditions met with at the floor girders, bilge, side frame, deck corner, and beam. It may be observed that if the floor girder is designed to resist the bending moment in condition (2), it is also strong enough to meet the docking condition in condition (4), where the bending moment is about two-thirds that of condition (2). In condition (3) the bending moment is reversed in direction and the floor tends to deflect downwards, caused by a bending moment approximately two-thirds of that causing the upward deflection in condition (2). To provide an estimate of the bending moment to be allowed for in the first instance, the framing was treated as a continuous girder, and the free bending moment calculated for the several spans. These were plotted on a straight base representing the neutral axis of the framing and the theoretical fixing moment lines drawn; at the points of junction between the floors, frames and beams—where the amounts of the fixing moments varied—the difference in bending moment was proportioned to the expression $\frac{I}{L}$ of the member on each side of the joint.

Diagram 2 on Fig. 6, page 338, indicates the bending moments as estimated by the approximate method for condition (2). Fig. 6A on this page shows the structural section of floor girder, and the respective moduli and neutral axes are indicated on the section.

Neutral axis above base

$$= n = \frac{B_s \cdot d_s^2 + 2\,m\,(A_c \cdot d_c + A_t \cdot d)}{2\,\{B_s \cdot d_s + m\,(A_c + A_t)\}} =$$

$$\frac{36 \times 4^2 + 2 \times 15\,(4.16 \times 2.7 + 3.85 \times 33.5)}{2\,\{36 \times 4 + 15\,(4.16 + 3.85)\}} = 9.1 \text{ in.}$$

Moment of inertia

$$= I = \frac{B_s \cdot n^3}{3} - \frac{B_s \cdot X^3}{3} + m \cdot A_t\,(d-n)^2 + m \cdot A_c\,(n-d_c)^2$$

$$= \frac{36 \times 9.1^3}{3} - \frac{36 + 5.1^3}{3} + 15 \times 3.85\,(33.5 - 9.1)^2 +$$

$$15 \times 4.16\,(9.1 - 2.7)^2 = 44{,}304 \text{ in.}^4$$

Frame spacing = 3 ft.

I per foot of spacing $= \frac{44{,}304}{3} = 14{,}768$ in.^{4}

I_s per foot of spacing $= \frac{14{,}768}{15} = 985$ in.^{4} for steel reinforcement.

Moment of resistance for steel $= M_{R.S.} = \frac{I_s}{d - n} =$

$\frac{985}{33.5 - 9.1} = 40.37$ in.^{3} With B.M. of 30 ton-ft., max. stress = 9 tons per square inch.

Moment of resistance for concrete $= M_{R.C.} = \frac{I}{n} =$

$$\frac{14{,}768}{9.1} = 1{,}623 \text{ in.}^3$$

Basis for Strength Calculation.—As a basis for calculation of strength, the figures in Tables I and II were adopted as working limits for safe stresses on concrete and steel.

The vessels are in course of construction at Barrow-in-Furness, and the sand and aggregate found locally have proved most satisfactory for a concrete mixture suitable for shipbuilding. The concrete adopted is formed of a rich mixture of 1 part cement, 1.2 parts sand, and 2.4 parts granite aggregate (by volume). The amount used weighs 84 lb. per cubic foot. The sand used is of a coarse nature, having the following sieve rest:—

Mesh of sieve.	Remaining percentage on sieve.
100 × 100 per inch	100 per cent.
50 × 50 per inch	61 per cent.
20 × 20 per inch	14 per cent.

The aggregate used consists of granite chippings from ¾ in. downwards, weighing 92.5 lb. per cubic foot. The proportionate amounts of cement, sand and aggregate to form 27 cub. ft. or 1 cub. yard of concrete are—

9 cub. ft. cement, 10.74 cub. ft. sand, 21.47 cub. ft. aggregate = 1 cub. yard.

= 757 lbs. cement + 1.192 lb. sand + 1.986 lb. aggregate = 3.935 lb.

= 0.34 tons cement + 0.53 ton sand + 0.89 ton aggregate = 1.76 tons.

Add to this 0.05 ton water = 1.81 tons per cubic yard of concrete.

For estimating purposes 1 ton of concrete contains 0.57 cub. yard = 15.4 cub. ft.; or 0.192 ton cement, 0.300 ton sand, and 0.508 ton granite.

TABLE I.—*Basis for Calculation of Strength for Concrete.*

Item.	Working Stress.	Ultimate Stress.
	lb. per sq. in.	lb. per sq. in.
Compression in beams	750	4,000
Compression direct	700	4,000
Shear	70	280
Adhesion	60	240
	100	500

TABLE II.—*Basis for Calculation of Strength for Steel.*

Item.	Working Stress.	Elastic Limit.	Ultimate Stress.
	tons per sq. in.	tons per sq. in.	tons.
Tension, spiral bars ..	9	23½	30 to 36
Tension, plain bars ..	7½	15	27 to 30
Compression	7½	15	27 to 30
Shear	5½	—	24

Machine mixing of concrete is preferable to hand mixing inasmuch as a standard and invariable mixture may be obtained, due to the use of automatic devices for the measurement of the various ingredients as well as of measurement of the time of mixing.

Particulars and Description of Hull.—There are shown on Figs. 2, 7, and 8, midship sections respectively for the ferro-concrete, a steel and a wooden ship, each designed for a deadweight carrying capacity of 1,150 tons. The particulars of the three ships are given in Table III.

TABLE III.—*Dimensions of Reinforced Concrete, Steel and Wood Ship of 1150 Tons Deadweight Carrying Capacity.*

—	Reinforced Concrete.	Steel.	Wood.
	ft. in.	ft. in.	ft. in.
Length	205 0	188 0	205 0
Breadth	32 0	30 3	36 0
Depth	19 6	17 3	18 9
Draught	15 6	14 6	16 6*
	tons.	tons.	tons.
Deadweight	1,150	1,150	1,150
Displacement (load) ..	2,350	1,800	2,400
Indicated horse-power (about)	400	400	400

—	Weights.		
	Reinforced Concrete.	Steel.	Wood.
	tons.	tons.	tons.
Steel in hull†	190	445	140
Remainder of hull ..	860	80	960
Machinery and boilers ..	80	80	80
Outfit‡	70	45	70
Deadweight	1,150	1,150	1,150
Load displacement ..	2,350	1,800	2,400

* Includes 12-in. wood keel.
† Includes hull castings and forgings.
‡ Includes anchors, cables, boats, auxiliary machinery, &c.

It will be noticed that the weight of steel in the ferro-concrete ship is about 42½ per cent. of that in the steel ship. This is not by any means such a large reduction as some writers on ferro-concrete ship construction have anticipated, nor is it probably the minimum quantity which we could have adopted, had we been prepared to incur a certain amount of risk in structural strength. In view, however, of this being our first venture in a new method of construction, we did not feel justified in reducing the strength until we had ascertained from experience how a ship constructed on this principle would act under ordinary conditions of service. One reason was that, should the vessel prove weak, it would be matter of the utmost difficulty to introduce additional stiffening and strength. A second and even more potent reason was that we were not justified in risking the safety of the ship or the lives of the men who might navigate her, for the purpose of endeavouring in the first ship to reduce to the minimum the quantity of steel that might be used. Actual service will perhaps give an indication where weight may be saved, either in the steel or concrete of the hull; and that such saving will ultimately to effected, even with identical methods of construction, we confidently anticipate. It must not be overlooked that the saving of steel effected, especially under present conditions, is of the greatest importance. If we take, say, 200 vessels similar to the one under discussion, we should have an additional carrying capacity of 230,000 tons added to our mercantile fleet, whilst there would be a total saving of 51,000 tons of steel as compared with a similar number of steel ships of equal carrying capacity. Moreover, this steel is worked in the form of reinforcement rods and is not dependent upon the plate rolling mills for its production. This is the more important, as at the present moment it is largely the limited output of the rolling mills which adds to the difficulty of procuring an adequate amount of shipbuilding steel.

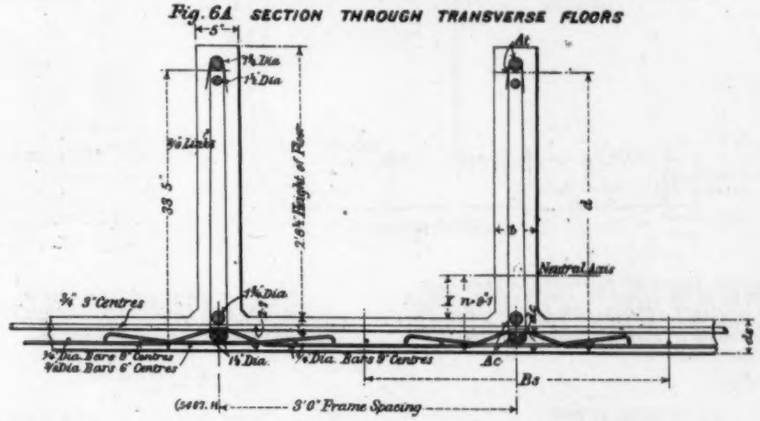
We came to the conclusion that the most economical as well as the most efficient rod for ship construction was that known as the spiral bond bar. This is an ordinary mild steel bar, which subsequent to being rolled is stressed by being twisted in such a manner that the elastic limit is raised about 35 per cent., the twist in the bar giving it at the same time a continuous mechanical bond with the concrete in which it is embedded. With this high elastic limit smaller sections may be employed than would be possible with an ordinary mild steel bar, which means a reduction in weight of steel used. As the continuous mechanical bond justified shorter overlapping of bars at junctions, the weight of steel is again reduced. A further advantage of the special twisting treatment is in the fact that steel of very low tensile strength may be thus treated, and so release for other important work the higher quality steel.

Table IV gives results of actual tests of a spiral bond bar (1¼ in. diameter) before and after twisting.

Although the structure of these vessels, both in relation to the shell and frames, is purely reinforced concrete throughout, the possibility of working the shell of ferro-concrete vessels in conjunction with ordinary frame bars or built-up frames has not been lost sight of, although the problems attendant on such a departure from a purely monolithic structure present difficulties. It is conceivable that a vessel might be satisfactorily constructed in which the ordinary steel frame is used in conjunction with the present system of reinforced concrete hull, and in the United States they appear to have adopted some such method. With our present knowledge there would appear to be in this connection an element of danger unless a system is used, blending together the parts in such a way as to leave no possible chance of disruption. The experience gained by American builders in this respect may help to solve this difficulty, as the principle, if successful, appears to be well worthy of adoption. It may indeed be essential in ferro-concrete ships of large tonnage. Such a system, too, would overcome some of the difficulties in connection with the fitting of various details, which, at present, it is necessary to arrange for before the concrete portion is commenced. A further advantage, and probably the principal one, is that without having to introduce a much greater proportion of skilled labour, the system would result in a decreased weight of hull.

Hull Fittings and their Connection.—Many problems have arisen regarding fittings and their connection and

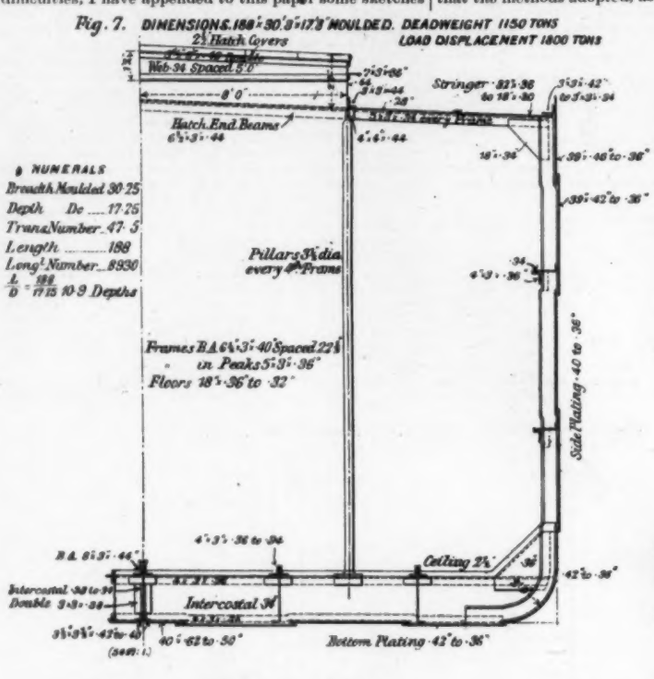
Fig. 6A. SECTION THROUGH TRANSVERSE FLOORS

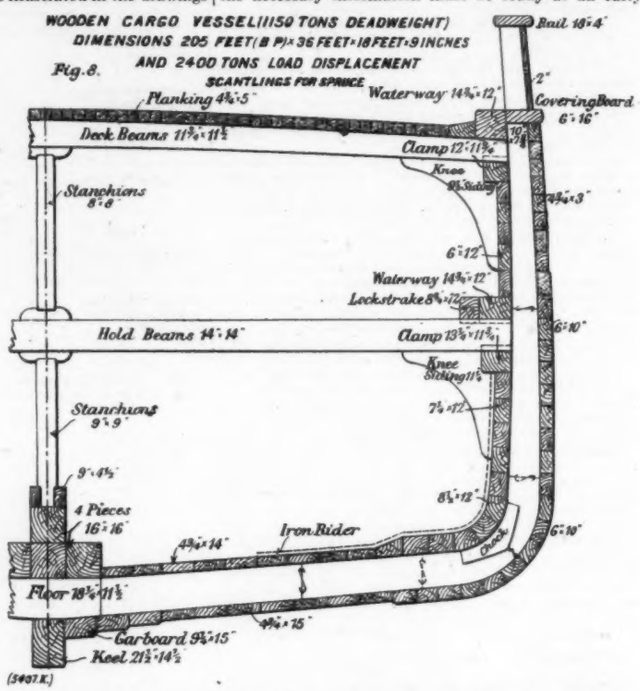


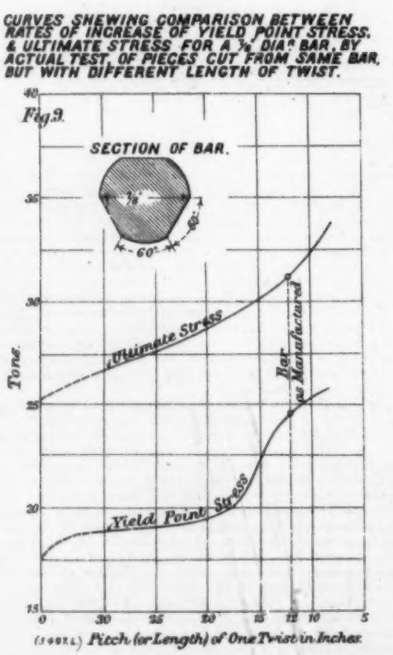
relation to the ship, which in ordinary steel construction are simple, but which, in the case of ferro-concrete construction, offer difficulties which have had to be carefully examined and overcome. Amongst these are the openings in the ship's bottom, stuffing-boxes, the passage of pipes through bulkheads, the connection of fittings to the bulkheads, and the connection of stanchions, fairleads, bollards, &c., to the deck. Added to these are important problems, such as the connection to the hull of the rudder post, stern post, and the stern tube. In order to illustrate some of the difficulties experienced and some of the means adopted to overcome these difficulties, I have appended to this paper some sketches showing how certain of these questions have been dealt with, such as, for instance :

Fig. 11, Plate XXXIII.—Arrangement of pillaring.
Fig. 12, Plate XXXIII.—Typical spigot for sea connections.
Fig. 13, Plate XXXIV.—Ceiling plan.
Fig. 16, Plate XXXV.—Stern Frame.

There is no doubt that, with experience, improved methods of adapting fittings and parts of the structure to their proper functions in economical and efficient manner will be evolved, but for the moment we think that the methods adopted, as illustrated in the drawings reproduced, are such as to give reasonable justification for anticipating efficient performance. In the case of a steel ship, if before the erection of the bulkhead provision has not been made and holes punched to take any particular fitting, as, for instance, a bracket, it is an easy matter to drill such holes afterwards to accommodate it. For a concrete vessel, however, the cutting of holes after the concrete has set is not easy and is undesirable. It is, therefore, highly important that all the details of fittings required to be connected to the hull, or passing through a bulkhead, for instance, should be considered before the erection and casting of that bulkhead, and the necessary information must be ready at an early stage of the construction in order that the builders may make suitable provision for the same when erecting the shuttering. Where it is necessary to leave a hole in the concrete, a wooden peg may be fastened to the shuttering in the required position ; but in the case of pipes passing through a deck or a bulkhead, a better arrangement is to cast a metal spigot in the concrete with suitable flanges or screwed ends projecting on each side for connection to the pipes. Such fittings as mooring pipes or hawse pipes, as well as the majority of small topside fittings, have to be specially designed, with proper projections, for casting into the concrete, as otherwise holes must be prepared to take the holding-down bolts.






CURVES SHEWING COMPARISON BETWEEN RATES OF INCREASE OF YIELD POINT STRESS & ULTIMATE STRESS FOR A ¾" DIA.R BAR, BY ACTUAL TEST, OF PIECES CUT FROM SAME BAR, BUT WITH DIFFERENT LENGTH OF TWIST.
Fig. 9.
SECTION OF BAR.
Ultimate Stress
Yield Point Stress
Bar as Manufactured
Tons
Pitch (or Length) of One Twist in Inches.

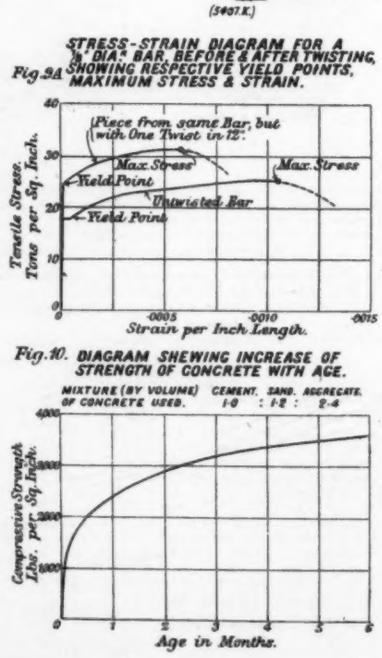

STRESS-STRAIN DIAGRAM FOR A ¾" DIA.R BAR, BEFORE & AFTER TWISTING, SHOWING RESPECTIVE YIELD POINTS, MAXIMUM STRESS & STRAIN.
Fig. 9A
(Piece from same Bar, but with One Twist in 12".)
Max. Stress
Yield Point
Untwisted Bar
Tensile Stress, Tons per Sq. Inch.
Strain per Inch Length.

Fig. 10. DIAGRAM SHEWING INCREASE OF STRENGTH OF CONCRETE WITH AGE.
MIXTURE (BY VOLUME) OF CONCRETE USED. CEMENT. 1·0 : SAND. 1·2 : AGGREGATE. 2·4
Compressive Strength Lbs. per Sq. Inch.
Age in Months.

TABLE IV.—TESTS OF SPIRAL BOND BAR (1⅜ IN. DIAMETER).

Original Size.			Contraction of Area.			Elongation in 8 in.		Ultimate Stress.		Elastic Limit.	
Diameter.		Area.	Diam.	Area.	Per Cent.	Inches.	Per Cent.	Actual Tons.	Tons per Sq. In.	Actual Tons.	Tons per Sq. In.
Before twisting,	1.375 in. ..	1·39	0·88	0·568	59·2	10·40	30·0	37·4	26·9	24·5	17·62
After twisting,	1.375 in. ..	1·39	0·89	0·581	58·2	9·68	21·0	41·3	29·7	33·2	23·86

See stress strain diagram, Fig. 9, above

Lines and Tank Trials.—It is obvious, in view of the fact that the whole of the vessel's hull has to be cast in moulds or shutters, that the simpler and straighter the lines of the vessel the more cheaply and easily the shuttering can be constructed, and the more rapidly the work can be proceeded with. For this reason, when designing the lines, a simple midship section was adopted having a perfectly straight side and bottom with only a very small curvature at the bilge. This section was retained in a parallel middle body for half the length of the vessel amidships, and the waterlines forward rounded into an easy entrance, still retaining, however, the straight-line sections. In rounding in the waterlines aft the straight-line sections were retained as far as possible and then run aft to the propeller and faired in with a minimum of curvature.

In determining the form two points had to be considered :—(1) That the fullness of form which is economical in ordinary cargo boats when coupled with moderately low speeds would certainly be desirable when the material of construction was such that the weight of hull accounted for a larger proportion of the displacement than in the case of a steel ship. (2) That the introduction of straight lines in the transverse sections, whilst desirable for constructional purposes, might lead to a large increase in resistance compared with an ordinary cargo boat form, if there were any tendency for the stream lines to flow across the knuckle (i.e., the intersection of the two surfaces forming the sides and bottom).

To obtain a reasonably good form under the above conditions, trials were carried out in the experimental tank as follows : The model was made fuller than was actually required and cast thick enough locally to allow cutting off at certain parts. After the curve of resistance had been obtained with the original model (C 8), Fig. 14, the bottom part of the bow was fined ($C S_2$) with an improved result. Then the after body was similarly fined ($C S_3$) with further advantage. A further fining of the bow ($C S_4$) and then again of the stern ($C S_5$) still improved the form, which was now reasonably comparable with an ordinary cargo boat form of the same dimensions and displacement. The total modifications

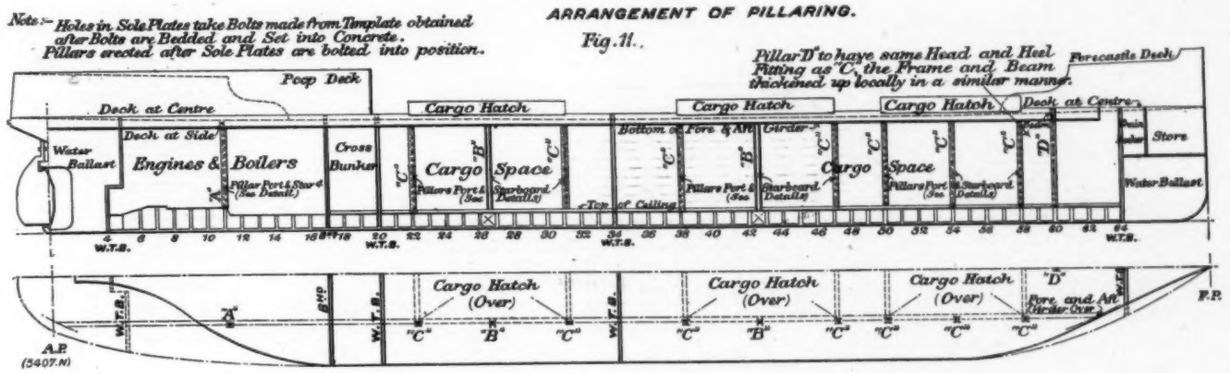
REINFORCED-CONCRETE SEA-GOING STEAMERS; CONSTRUCTIONAL DETAILS.

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, BARROW-IN-FURNESS.

(For Description, see Page 335.)

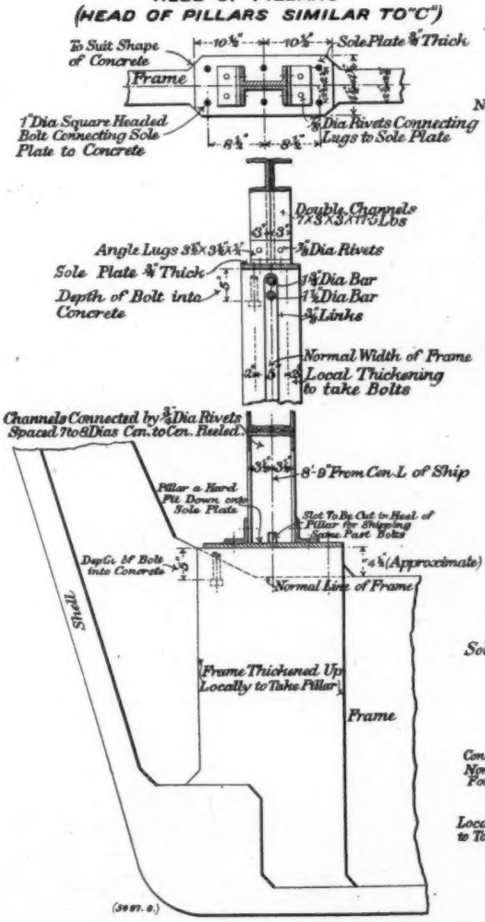
ARRANGEMENT OF PILLARING.

Fig. 11.

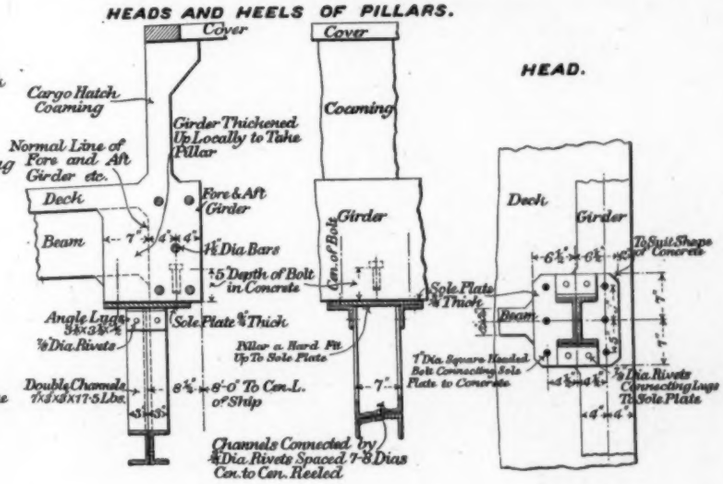

Note:—Holes in Sole Plates take Bolts made from Template obtained after Bolts are Bedded and Set into Concrete. Pillars erected after Sole Plates are bolted into position.
Pillar 'D' to have same Head and Heel Fitting as 'C' the Frame and Beam thickened up locally in a similar manner.
Poop Deck
Deck at Centre
Deck at Side
Cargo Hatch
Cargo Hatch
Cargo Hatch
Deck at Centre
Forecastle Deck
Water Ballast
Engines & Boilers
Cross Bunker
Cargo Space
Cargo Space
Stores
Water Ballast
Top of Ceiling
Cargo Hatch (Over)
Cargo Hatch (Over)
Cargo Hatch (Over)
Fore and Aft Girder Over
A.P.
F.P.

HEADS AND HEELS OF PILLARS.

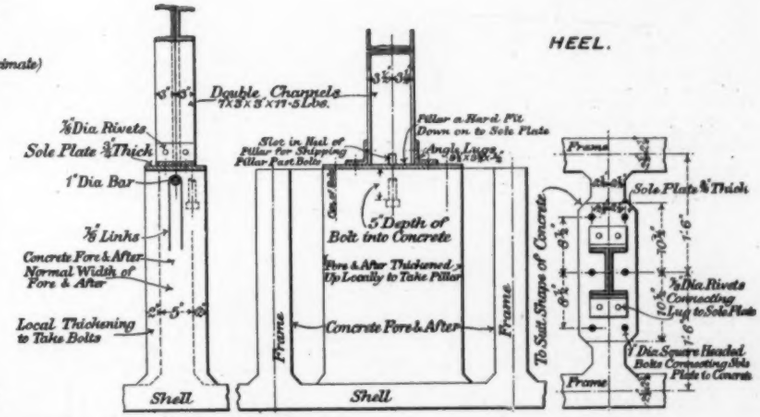
HEEL OF PILLARS (HEAD OF PILLARS SIMILAR TO "C")


To Suit Shape of Concrete
Sole Plate ⅝" Thick
Frame
1" Dia. Square Headed Bolt Connecting Sole Plate to Concrete
⅞" Dia. Rivets Connecting Lugs to Sole Plate
Double Channels 7"x3"x3"x11·5 Lbs.
Angle Lugs 3½"x3½"x½"
⅞" Dia. Rivets
Sole Plate ⅝" Thick
1¼" Dia. Bar
Depth of Bolt into Concrete
1¼" Dia. Bar
⅝" Links
Normal Width of Frame
Local Thickening to take Bolts
Channels Connected by ⅞" Dia. Rivets Spaced 7 to 8 Dias Cen. to Cen. Reeled
8'-9" From Cen. L. of Ship
Pillar a Hard Fit Down onto Sole Plate
Slot To Be Cut in Heel of Pillar for Shipping Some Part Bolts
Depth of Bolt into Concrete
4½" (Approximate)
Normal Line of Frame
Shell
Frame Thickened Up Locally to Take Pillar
Frame

HEAD.

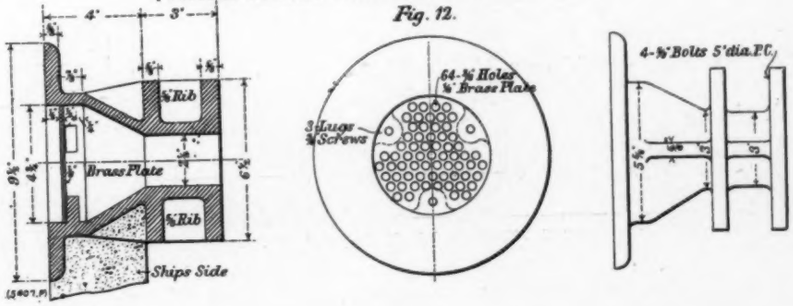

Cover
Cover
Cargo Hatch Coaming
Girder Thickened Up Locally to Take Pillar
Normal Line of Fore and Aft Girder etc.
Coaming
Deck
Fore & Aft Girder
Girder
Beam
¾" Dia. Bars
5" Depth of Bolt in Concrete
Angle Lugs 3½"x3½"x½"
Sole Plate ⅝" Thick
⅞" Dia. Rivets
Pillar a Hard Fit Up To Sole Plate
Double Channels 7"x3"x3"x11·5 Lbs.
8'-0" To Cen. L. of Ship
Channels Connected by ⅞" Dia. Rivets Spaced 7-8 Dias Cen. to Cen. Reeled
Deck
Girder
To Suit Shape of Concrete
Sole Plate ⅝" Thick
Beam
1" Dia. Square Headed Bolt Connecting Sole Plate to Concrete
⅞" Dia. Rivets Connecting Lugs To Sole Plate

HEEL.


Double Channels 7"x3"x3"x11·5 Lbs.
⅞" Dia. Rivets
Sole Plate ⅝" Thick
1" Dia. Bar
⅝" Links
Concrete Fore & After
Normal Width of Fore & After
Local Thickening to Take Bolts
Pillar a Hard Fit Down on to Sole Plate
Slot in Heel of Pillar for Shipping Pillar Part Bolts
Angle Lugs 3½"x3½"x½"
5" Depth of Bolt into Concrete
Fore & After Thickened Up Locally to Take Pillar
Concrete Fore & After
Frame
Frame
Shell
Shell
Frame
Sole Plate ⅝" Thick
⅞" Dia. Rivets Connecting Lug to Sole Plate
1" Dia. Square Headed Bolts Connecting Sole Plate to Concrete
To Suit Shape of Concrete

TYPICAL SUCTION CONNECTION ON SHIPS SIDE

Fig. 12.

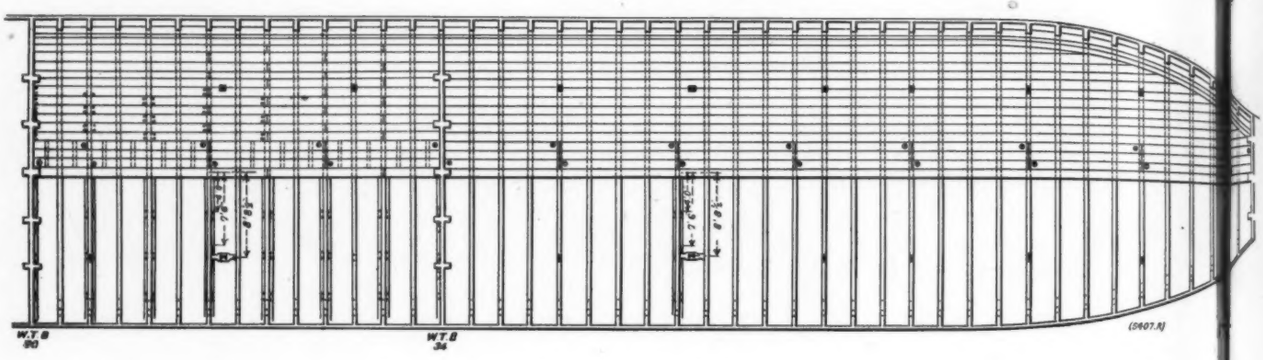


(To face page 340.)

REINFORCED-CONCRETE SEA-GOING STEAMERS; CONTRU

CONSTRUCTED BY THE FERRO-CONCRETE SHI CONSTR

(For Descripti Page 3



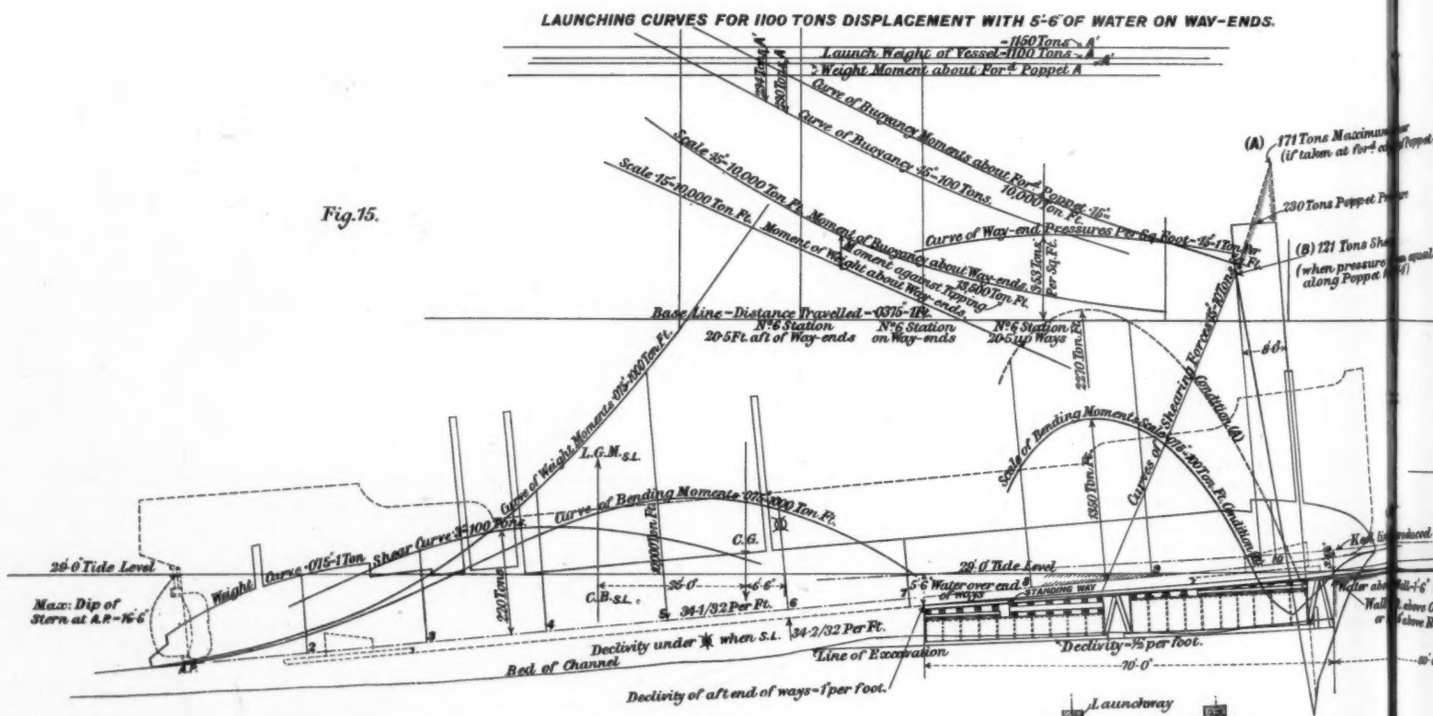
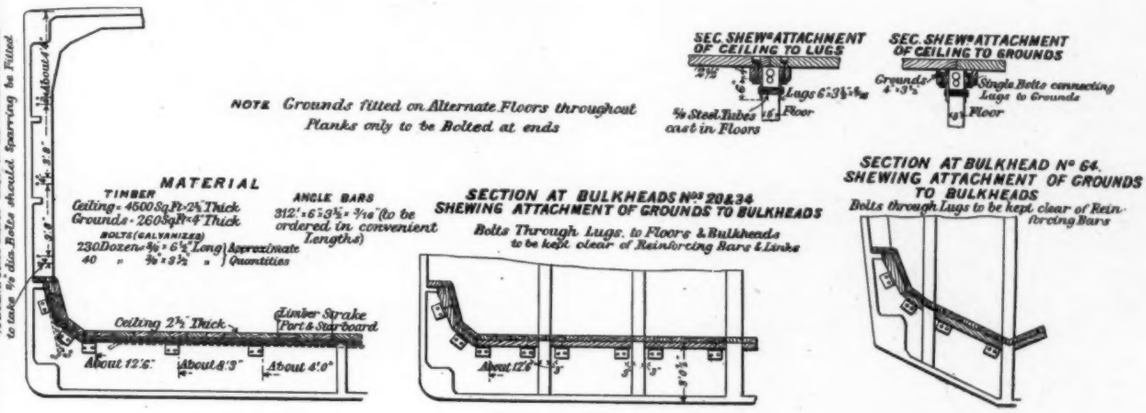

LAUNCHING CURVES FOR 1100 TONS DISPLACEMENT WITH 5'-6" OF WATER ON WAY-ENDS.
Launch Weight of Vessel-1100 Tons
Weight Moment about For.d Poppet A
Curve of Buoyancy Moments about For.d Poppet
Curve of Buoyancy-35'-100 Tons.
Scale 35'-10000 Ton. Ft.
Scale 15'-10000 Ton. Ft.
Moment of Weight about Way-ends
Curve of Way-end Pressures Per Sq. Foot
(A) 171 Tons Maximum
230 Tons Poppet
(B) 121 Tons Sh
Base Line-Distance Travelled-0315-1Ft.
N.o 6 Station 20·5 Ft. aft of Way-ends
N.o 6 Station on Way-ends
N.o 6 Station 20·5 up Ways
Curve of Weight Moments
Curve of Bending Moments
Scale of Bending Moments
Curves of Shearing Forces
Gradient (A)
L.G.M.
C.G.
C.B.
26'-0" Tide Level
Max.m Dip of Stern at A.P.-16'-6"
Weight Curve-015-1 Ton.
Shear Curve
220 Tons
34-1/32 Per Ft.
Declivity under ✱ when S.L.
Bed of Channel
Line of Excavation
Declivity-½ per foot.
70'-0"
Declivity of aft end of ways-1 per foot.
29'-0" Tide Level
5'-6" Water over end of ways
STARBOARD WAY
Keel line produced
Water above Wall 11'-6" above C
Wall above B
MIDSHIP SECTION.
Weight...5 Tons per foot run.
Pressure on ground spread to give 1½ Tons per Sq. Ft.
Pressure on Launchways-1⅞ Tons per Sq. Ft.
14'-0"
SLIDING WAY STARBOARD 1'-10"×1'
2" Boards
Ferro-Concrete Blocks 4'-6" apart.
F.C. Keel Blocks req.d for 1 Ship.
2 Tiers of Centre Keel Blocks 4'-6" apart 90 off 5'-0"×16"×12"
1 Tier " Bilge " " 20 off 4'-0"×16"×12"
Ferro-Concrete Slab & Block combined, built in situ, spaced 4'-6" apart.
Launchway
Sand of Channel
12'-6"
ELEVATION OF LAUNCHWAYS IN CHANNEL.
See Alternative arrgt. using pontoons.
Pontoon
30'-3"×7'-0"×4'-0"
30'-3"×7'-6"×6'-0"
D.o
Sand
3'-0"
2'-6"
Reinforced Concrete Slabs on
Pressure of Ways 3 Tons per Sq.
Pressure on each slab 8'-6" apa
Load when Poppet finally tra
N.o of F.C. Launching Blocks re
N.o of F.C. Launching Slabs on Bed of Channel-40 per Ship.

Fig. 15.

CONSTRUCTIONAL DETAILS AND LAUNCHING DIAGRAM.

TE SHIPBUILDING CONSTRUCTION COMPANY, BARROW-IN-FURNESS.

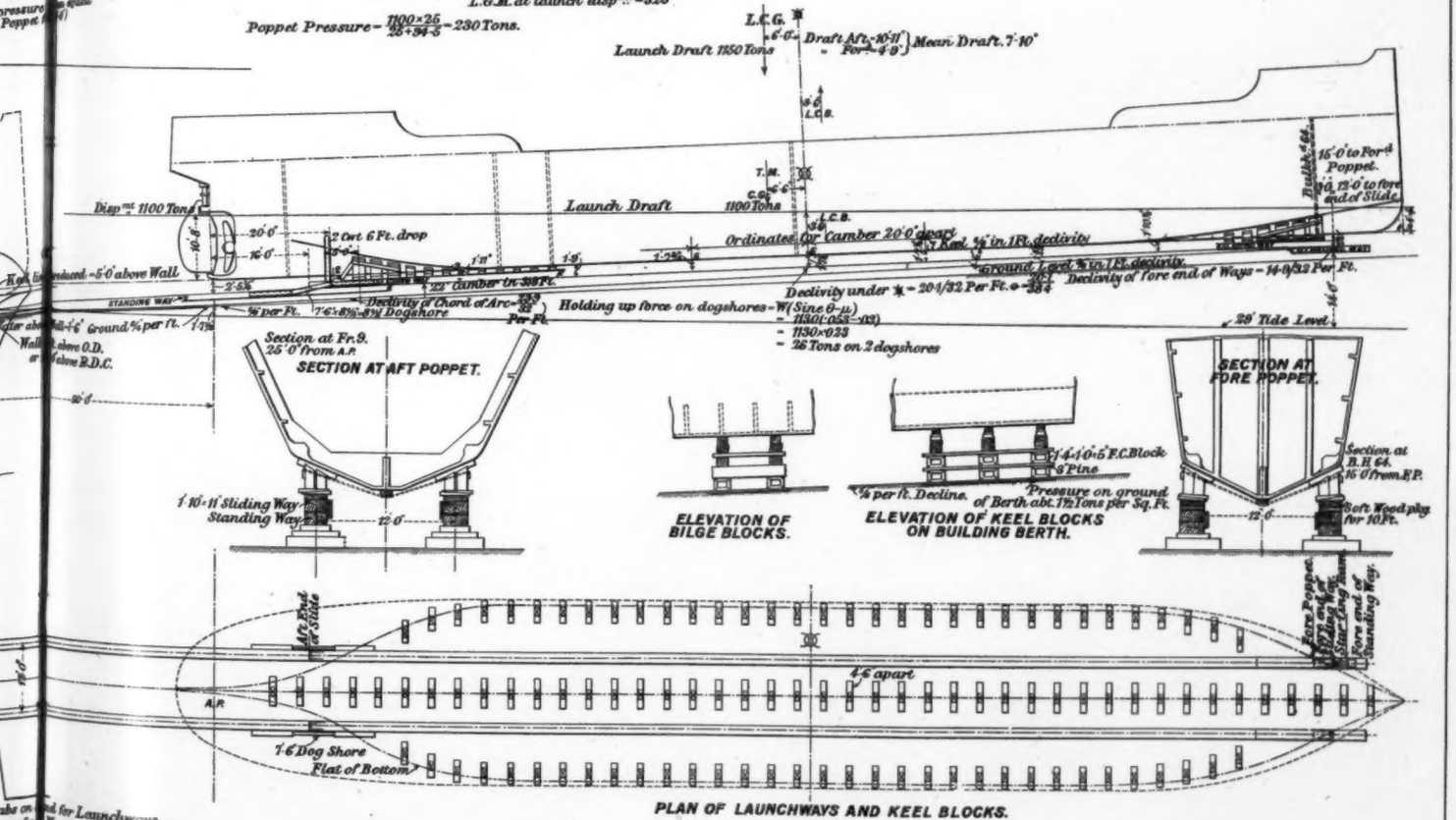
(Description Page 335.)


MATERIAL
TIMBER
Ceiling - 4500 Sq.Ft. 2½" Thick
Grounds - 260 Sq.Ft. 4" Thick
BOLTS (GALVANIZED)
230 Dozen ⅝" × 6½" Long
40 " ⅝" × 3½" "
ANGLE BARS
312' × 6" × 3½" × ⅜" (to be ordered in convenient Lengths)
Approximate Quantities
NOTE Grounds fitted on Alternate Floors throughout
Planks only to be Bolted at ends
SEC. SHEWING ATTACHMENT OF CEILING TO LUGS
SEC. SHEWING ATTACHMENT OF CEILING TO GROUNDS
Lugs 6" × 3½" × ⅜"
Floor
Grounds 4" × 3½"
Single Bolts connecting Lugs to Grounds
⅝" Steel Tubes cast in Floors
SECTION AT BULKHEADS Nos 20 & 34
SHEWING ATTACHMENT OF GROUNDS TO BULKHEADS
Bolts Through Lugs, to Floors & Bulkheads to be kept clear of Reinforcing Bars & Links
SECTION AT BULKHEAD No 64.
SHEWING ATTACHMENT OF GROUNDS TO BULKHEADS
Bolts through Lugs to be kept clear of Reinforcing Bars
Ceiling 2½" Thick.
Timber Strake Port & Starboard
About 12'6"
About 8'3"
About 4'0"
About 12'6"

Declivity of Keel on Berth ..... 20/32 Per Foot
Extra declivity when Stern lifts minus that due to Camber } 34·2 - 20·1 = 14·1/32 " "
Declivity of Keel when Stern lifts ..... 34·1/32 " "
Subtract Trim of Ship afloat ..... 11·6/32 " "
Excess Trim ..... = 22·5/32 " "

Height of $L.G.M._{S.L.} \times \frac{22.5}{32} = 25' - C.B._{S.L.}$ aft. of C.G.
$\therefore L.G.M._{S.L.} = 430' - 1·32$ times L.G.M. at launch disp^{mt}
L.G.M. at launch disp^{mt} = 325'

Poppet Pressure = $\frac{1100 \times 26}{26 + 34·5} = 230$ Tons.


L.C.G.
Launch Draft 1150 Tons
Draft Aft 10'11"
For 4'9"
Mean Draft 7'10"
L.C.B.
Disp^{mt} 1100 Tons
Launch Draft
1100 Tons
Ordinates Cor Camber 20'0" apart
½" Rad. ½" in 1 Ft. declivity
Ground 1 rad. ½" in 1 Ft. declivity
Declivity of Fore end of Ways = 14·6/32 Per Ft.
15'0" to For^{d} Poppet.
12'0" to fore end of Slide
2 Ord. 6 Ft. drop
22" Camber in 38 Ft.
Declivity of Chord of Arc = 22·5/38 Per Ft.
Declivity under ⅛ = 20·1/32 Per Ft. = 38·4
Holding up force on dogshores = W (Sine θ - μ)
= 1130 (·033 - ·03)
= 1130 × ·033
= 26 Tons on 2 dogshores
28' Tide Level
Section at Fr. 9. 25'0" from A.P.
SECTION AT AFT POPPET.
SECTION AT FORE POPPET.
Section at B.H. 64. 15'0" from F.P.
1'10" Sliding Way
Standing Way
12'0"
ELEVATION OF BILGE BLOCKS.
4'4" × 1'0" × 6" F.C. Block
6" Pine
⅛" per Ft. Decline.
Pressure on ground of Berth abt. 1½ Tons per Sq. Ft.
ELEVATION OF KEEL BLOCKS ON BUILDING BERTH.
Soft Wood plug for 10 Ft.
4'6" apart
A.P.
1'6" Dog Shore
Flat of Bottom
Fore Poppet
Fore end of Standing Way

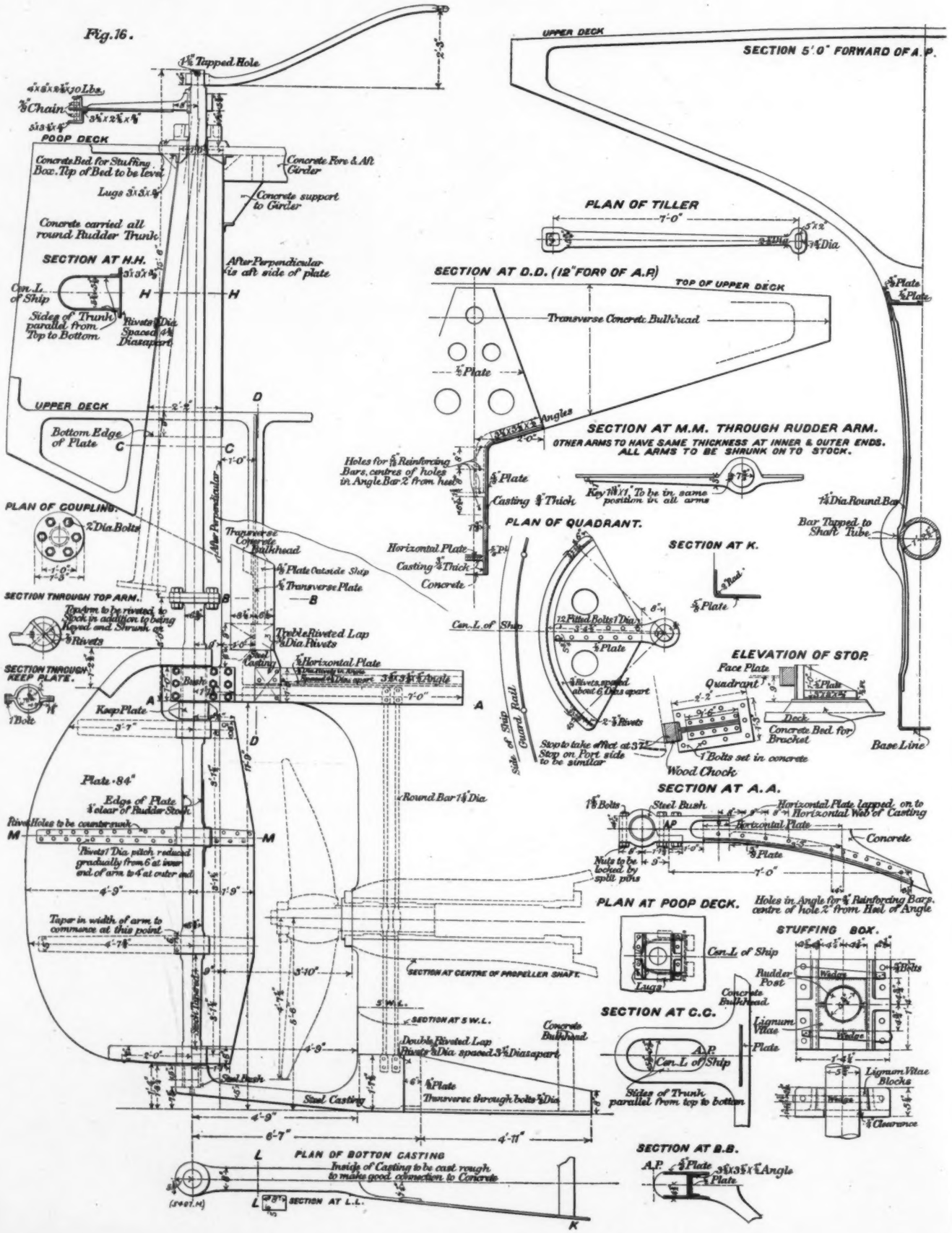
PLAN OF LAUNCHWAYS AND KEEL BLOCKS.

for Launchways.
Way-end pressure.
21 Tons on 20 Sq. Ft. area.
down - double the above.
Berth. 5'0" × 16" × 12" × 3'6" apart = 120
Channel. 80 @ 5'0" × 16" × 12" } = 160
80 @ 5'0" × 18" × 12" }
280 off

REINFORCED-CONCRETE SEA-GOING STEAMERS; THE STERN FRAME.

CONSTRUCTED BY THE FERRO-CONCRETE SHIP CONSTRUCTION COMPANY, BARROW-IN-FURNESS.

(For Description, see Page 335.)



(To face page 341.)

made were comparatively slight, amounting to 23 tons, and reducing the block coefficient by .01.

The load waterline and curve of areas have generally been regarded as the determining feature of the resistance of an ordinary form, but we found that the influence of the knuckle was so marked that, with the waterline unaltered and practically the same curve of areas, a reduction was made in resistance of 40 per cent.

The lines plan, Fig. 3 (page 337), shows in dotted lines the model as originally tried corresponding to the CS form on the tank results diagram, Fig. 14, and the full lines on the lines plan show the lines to which the ship is actually being built and correspond to the last trial in the tank and to the CS_5 form on the tank results diagram. It was not considered necessary to show the intermediate modifications on the lines plain. The lines ultimately adopted may, therefore, very reasonably be considered as the most suitable for simplicity of shuttering and for easy construction in ferro-concrete. The deck has a camber of 8 in. in the full breadth; but here again curvature has been avoided, the crown being a level flat 4 ft. each side of the centre line, the remaining deck sloping in a straight line to the side, as shown on the lines plan, Fig. 3, and the deck at centre is a straight line all fore and aft.

Propelling Machinery and Boilers.—With respect to the propelling machinery, the considerations which have to be taken into account as to suitability of type are practically the same in ferro-concrete as in steel ships; but the method of efficiently connecting the machinery to the hull of the ship, the arrangement of the stern tubes, the special attachment to the shell of sea connections, &c., require more consideration in the former case, and great care has to be taken to ensure reliability in this respect. In the present six boats building to this design the adoption of machinery has been largely governed by what it has been possible to obtain under existing circumstances. In three of the vessels we are fitting compound surface condensing single-screw engines of approximately 350 h.p. to 400 h.p. with cylinders 17-in. and 34-in. diameter, 24-in. stroke working at about 100 r.p.m. The boiler installation consists of two cylindrical boilers 9 ft. 6 in. diameter by 9 ft. long, working at a pressure of about 130 lbs. In the remaining three we intend fitting triple-expansion engines of about 500 i.h.p., which will somewhat reduce our deadweight capacity but give an appreciable increase of speed. Two boilers were decided upon, so that in the case of a breakdown of one there would be sufficient, boiler-power in the ship to drive the vessel at a reasonable speed. When in port one of the boilers will be of sufficient power to work all necessary auxiliary machinery, including that for loading or discharging. Incidentally, there are other advantages in having two small boilers, such as the possibility of their transport by rail instead of by sea from the place of manufacture to wherever the machinery is being installed. There is, too, the advantage of being able to ship the boilers through the hatchways, as leaving any part of the deck unfinished for this purpose is very undesirable in ferro-concrete ships. The machinery is fitted aft, a usual position in this type of cargo vessel; but another reason for this was to reduce the length of tunnel, as if this were of ferro-concrete instead of steel it would form an important item of weight.

Launching.—Coming next to the question of launching, this is an operation which, in the case of ferro-concrete ships, requires more than ordinary consideration and care. This operation, always fraught with anxiety, is doubly so when dealing with a vessel of ferro-concrete construction. Take, for instance, the launching arrangements for the vessel under discussion. A launching weight of 1,100 tons has to be dealt with as compared with about 550 tons in the case of a steel ship of corresponding size. To keep down the stresses, a moderate declivity of ways with ample depth of water on the way ends has been arranged; but, even so, quite a considerable hogging stress and excessive way-end pressures are met with just before the stern commences to lift. Some internal shoring has to be arranged at suitable parts of the vessel as additional precautions before launching. The shearing forces at the fore poppet are severe and must be met by an adequate strength of hull. The foundation supports, especially as the vessel is being built on new ground, have been carefully considered, as sinkage during any stage of the concreting would have serious results and must be guarded against. The precaution of allowing the concrete sufficient time to set properly before the vessel is launched is necessary in view of the fact that the compressive strength of the concrete continues to increase for some time after being worked, and it is necessary to utilise as much of this increased strength as possible to resist the launching stresses. Fig. 10, page 340, shows this increase of compressive strength on a base of months. The supporting blocks and holding-up arrangements (dog shores) also require greater strength than is necessary in the case of the lighter steel vessels. A sketch showing the arrangement made is given on Fig. 15 (Plate XXXIV), and shows very fully the practical arrangements as well as the curves of stresses under all conditions likely to be met with. Generally speaking, the severe launching conditions may be taken as an adequate test of the vessels' ability to withstand any stresses she may be called upon to meet under ordinary conditions of service.

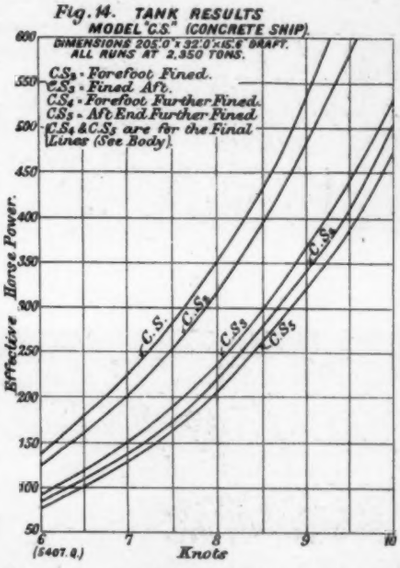
LAUNCH PARTICULARS.

Item.	
Length of standing ways... ...	313 ft. + 6 ft.
Camber in 313 ft....	22 ft.
Length and breadth of sliding ways	164 ft. × 22 in.
Area of sliding ways	600 sq. ft.
Launch displacement	1,100 tons.
Weight on standing ways... ...	1,130 tons.
Pressure per sq. ft. on ways ...	1.88 tons. per sq. in.
C. G. aft of amidships	6.5 ft.
Poppet Pressure	230 tons.
Moment against tipping	13,500 tons.
Bending moment on overhanging stern	10,000 ton ft.
Stress on concrete...	350 lbs. per sq. in.
Tensile stress on reinforcement ...	5½ tons per sq. in.
Minimum water on way ends ...	5 ft. 6 in.

To obviate the undesirable necessity of pile-driving in the channel where the vessel is being built, the standing ways beyond the sea-wall are supported on specially designed pontoons resting on the bed of the channel. These pontoons are specially constructed of concrete and may be towed from one berth to another, and when in the necessary positions are sunk by being flooded through sluice valves arranged in the sides for that purpose (see Fig. 15).

Some statement should perhaps be made here as to the time for construction of vessels of this type as compared with steel ships, and our experience so far leads us to believe that in the case of the first vessel of any type, the time of construction approximates very closely to that of a steel ship, but that in building successive ships of the same size and form there will be a marked reduction owing to the possibility of using repeatedly a large proportion of the shuttering or moulds. By this means I

Fig. 14. TANK RESULTS MODEL "C.S." (CONCRETE SHIP).


DIMENSIONS 205.0 × 32.0 × 15.6 DRAFT.
ALL RUNS AT 2,350 TONS.
CS1 - Forefoot Fined.
CS2 - Fined Aft.
CS3 - Forefoot Further Fined.
CS4 - Aft End Further Fined.
CS4 & CS5 are for the Final Lines (See Body).
Effective Horse Power.
Knots
(5407.4.)

believe that, with all the material to hand, a vessel similar to that described in this paper could be completed in three and a half to four months.

I regret that neither time nor space allow me to indicate other types under construction in the yard, all possessing interesting characteristics. When completed their performances will no doubt add a helpful contribution to the study of ferro-concrete construction as applied to shipbuilding. Neither can I touch on the question of the application of discard steel for constructional purposes, as largely advocated by some builders, nor on the future possibilities of ferro-concrete as applied to shipbuilding when the time arrives when we shall not be driven to its adoption by stress of war conditions.

I admit some limitations in the paper, due to absence of precise knowledge and experience of the sea tests of the ships, but I hope to have the honour on another occasion of completing this contribution by giving the service results of the vessels described, when opportunity will probably occur to deal with other points omitted from the present paper. In conclusion, I should like to express a word of thanks to those associated with me in this work: the members of the staff of the Ferro-Concrete Ship Construction Company, of Barrow-in-Furness, who have worked so energetically and untiringly in the design and construction of the vessels; and to the directors and staff of Messrs. L. G. Mouchel and Partners, who have brought great ability and experience to bear on the solution of some of the difficult problems involved; also to the directors of the Yorkshire Hennebique Company, who have by their experience shown us how, in many ways, the time of construction can be shortened.

COAL SAVING.—The February number of *A Thousand and One Uses for Gas*, the monthly illustrated publication of the British Commercial Gas Association, 47, Victoria-street, Westminster, S.W. 1, deals with the use of gas-coke for steam raising. It contains an article giving a large number of particulars which go to prove the economy, alike from an individual and a national point of view, effected by the use of coke instead of crude coal in steam-raising plants. Illustrations show the number, variety and importance of commercial and other undertakings which have already made the change to great advantage. An interesting section of the article deals with the use of coke as a fuel for road transport, in which capacity it is being largely employed to-day. Copies of the number can be obtained from the Secretary of the Association, 3*d.*, post free.

8,750 K.V.A. TURBO-GENERATOR AT VASTERAS.

On page 342 we give illustrations of a steam turbine generator which has recently been installed as a reserve plant at Vasteras in connection with the Alfkarleby State hydro-electric power station. This plant is intended to maintain the output of the station during periods of low water supply.

The set was built by the General Electric Company, of Sweden, whose headquarters are also at Vasteras. The unit is designed to deliver 8,750 k.v.a., the normal running speed being 3,000 r.p.m. The high output at the speed stated is said to constitute a record for Scandinavia. The turbine is of the compound De Laval type. The general characteristics of the set are well set forth in Fig. 1, whilst Figs. 2 and 3 show views of the rotor for the generator, which is, it will be seen, of the type originated by Mr. C. E. L. Brown. The rotor forging is in one piece, and cored from end to end. This was done to ensure the quality of the material, which is nickel-steel. The core which was removed by a trepanning tool is shown alongside the rotor in our illustration. It was 4,900 mm. long.

The windings are maintained in place by long wedges, and provision is made for the entrance of ventilating currents below the windings in the usual way. The end caps are of steel, and have fans mounted on them as indicated. At 25 per cent. over speed the peripheral velocity of the rotor is 456 ft. per second, so that the centrifugal forces are high. The stator stampings are keyed into their places on the stator frame, which is, it will be seen, made in halves, the joint being in a plane transverse to the axis of the machine. The windings are arranged as symmetrically as possible and very securely stayed so as to be capable of withstanding the heavy loading which would result from a short circuit.

NOTICES OF MEETINGS.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, April 2, at 6 p.m. Paper by Mr. J. H. Anderson, on "The Storage of Bituminous Coal," with reference to its Liability to Spontaneous Combustion in Storage Heaps, Bunkers or Cargo. Friday, April 5, at 6 p.m. Annual meeting.

PERSONAL.—Messrs. Gaston, Williams and Wigmores, Limited, of International Buildings, Kingsway, in consequence of their premises being required by the Army Council, have moved their executive and general offices to 20, Bishopsgate, London, E.C. 2. Their telephone numbers will be London Wall 3040 (4 lines).

THE IRON AND STEEL INSTITUTE.—The annual meeting of the Iron and Steel Institute will be held on Thursday and Friday, May 2 and 3, in the Hall of the Institution of Civil Engineers, Great George-street, Westminster. On Thursday the meeting will commence with the usual business dealing with the report and the statement of accounts for 1917, and then the president-elect, Mr. Eugène Schneider, will deliver his presidential address. After that a selection of papers will be read and discussed up till 1 p.m. On Friday, May 3, awards of grants for the Andrew Carnegie Research Fund will be announced, and afterwards further papers will be read and discussed. Probably the meeting will be continued in the afternoon. Below we give a list of the papers, but it is possible that the publication of some of them will be restricted by the Censor. The order of the reading of the papers has not yet been settled. List of papers:—1. Presidential address by Mr. C. Eugène Schneider. 2. Report of the Blast-Furnace Committee: "Practical Points affecting Yield and Efficiency of Blast Furnaces." 3. Mr. G. D. Cochrane, "Importance of Coke Hardness." 4. Dr. F. H. Hatch, "Economic Value of the Jurassic Iron Ores of Great Britain." 5. Mr. T. C. Hutchinson, "Fuel Economy in Blast Furnaces." 6. Mr. A. Lennox Leigh, "Economy in Gas Cleaning." 7. Mr. Kenneth Chance, "Potash Recovery from Blast Furnaces." 8. Mr. E. H. Lewis, "Manufacture of Portland Cement from Blast-Furnace Slag." 9. Dr. J. E. Stead, "Blast-Furnace Bears." 10. Dr. A. MacWilliam, "Technical Aspects of the Establishment of the Heavy Steel Industry in India, with Results of some Researches connected therewith." *11. Mr. B. Talbot, "Production of Sound Steel by Lateral Compression of the Top Portion of the Ingot." *12. Mr. J. N. Kilby, "Steel Ingot Defects." (* Probably not available for distribution.) 13. Dr. J. E. Stead, "Notes on Inclusions in Steel and Ferrite Lines." 14. Mr. A. McCance, "Non-Metallic Inclusions in Steel." 15. Dr. W. Rosenhain and Mr. D. Hanson, "A Cause of Brittleness in Mild Steel Boiler Plates." 16. Mr. E. F. Law, "Effect of Mass on Heat Treatment." 17. Mr. J. H. Whiteley, "Effect of Cold Work on the Divorce of Pearlite." 18. Mr. J. A. van den Broek, "Effect of Cold Working on the Elastic Properties of Steel." 19. Dr. J. E. Stead, "Iron, Carbon and Phosphorus." 20. Colonel N. Belaiew, "Damascene Steel." 21 Dr. J. N. Friend, "Protection of Iron with Paint against Atmospheric Corrosion." 22. Mr. W. R. Schoeller and Mr. A. R. Powell, "Determination of Cobalt and Nickel in Cobalt Steel." The autumn meeting will be held on Thursday and Friday, September 12 and 13, 1918, also in the rooms of the Institution of Civil Engineers.

8,750-K.V.A. COMPOUNDED DE LAVAL TURBO-GENERATOR AT VÄSTERAS.

CONSTRUCTED BY THE GENERAL ELECTRIC COMPANY OF SWEDEN, VÄSTERAS.

(*For Description, see Page* 341.)]

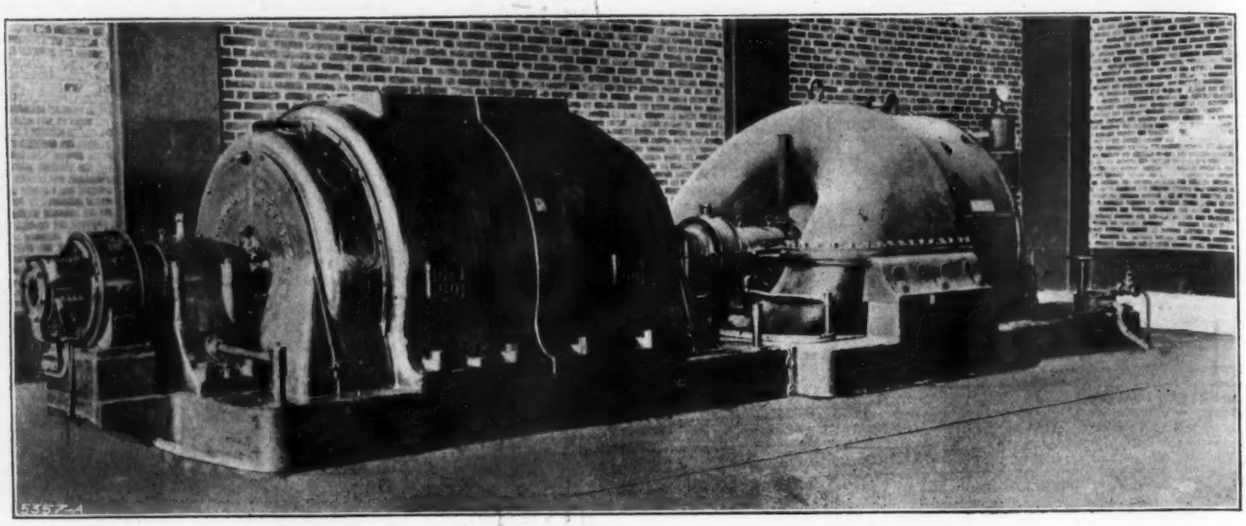


FIG. 1.

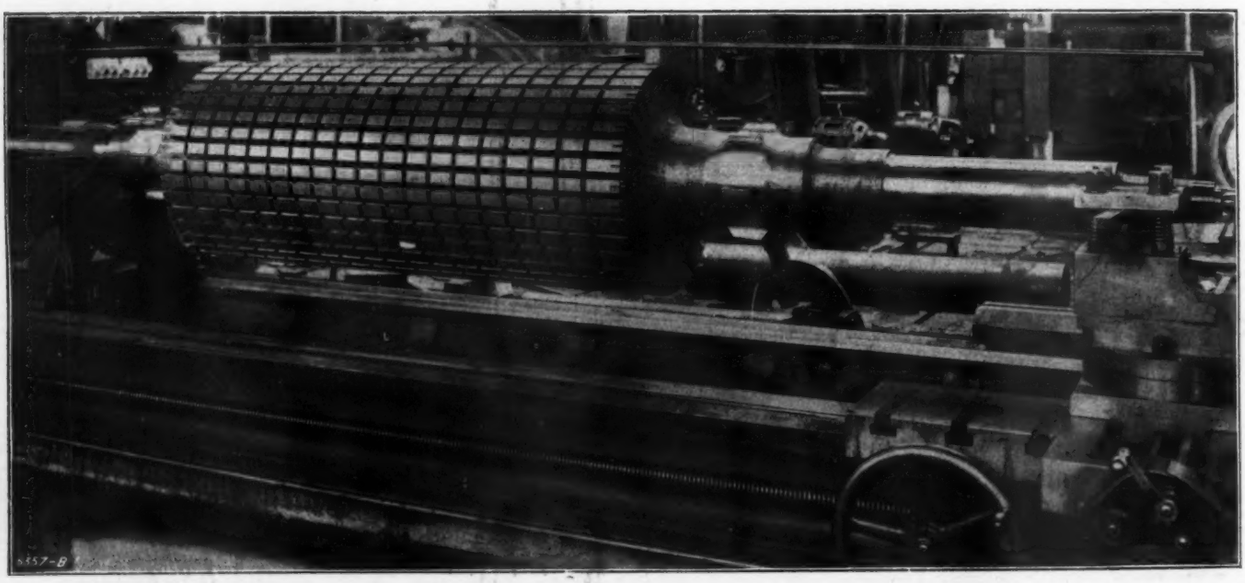


FIG. 2.

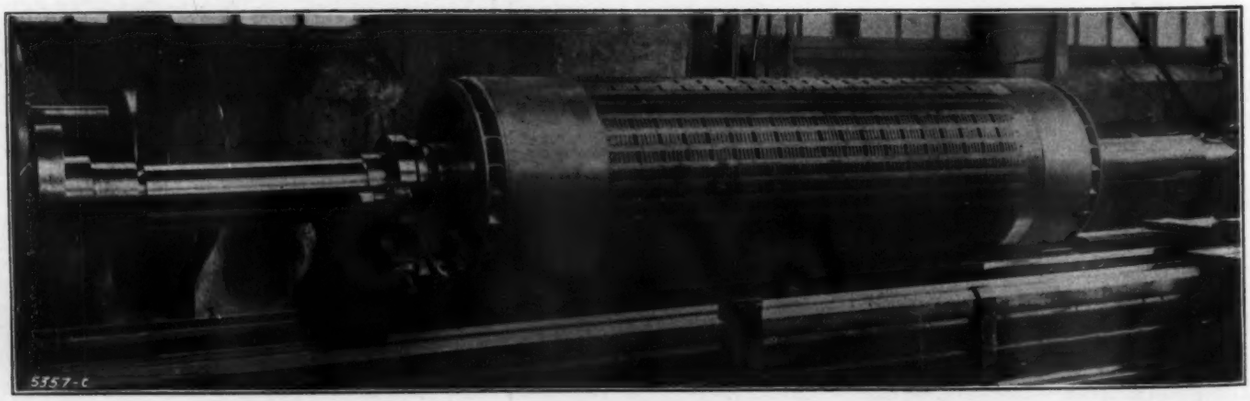


FIG. 3.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 3598 GERRARD.

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With One Two-Page Plate and Two One-Page Plates of REINFORCED-CONCRETE SEA-GOING STEAMERS.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 3d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 341.

ENGINEERING.

FRIDAY, MARCH 29, 1918.

THE CANAL QUESTION.

THE Prime Minister is reported to have said last week to a deputation of the Trade Union Congress that he was anxious that a system should exist in this country similar to that in France and Germany, where canals and waterways are utilised to their fullest extent. In view of this, special importance attaches to information given in "The Handbook on Canals," recently issued by the Canal Control Committee of the Board of Trade, giving information relating to our inland navigations, which are now under Government control. The canals owned by the railway companies became "controlled" in the early days of the war. The independently-owned canals were placed under State control early in 1916. This "Handbook," besides containing particulars of the inland waterways, their traffic, and the districts served by them, gives an account of what has been accomplished under the new scheme of State supervision. Unfortunately, the results are not very gratifying. They certainly fall far short of what were predicted by the advocates of "control." The best that is claimed by the Controllers is that "the very serious drop in traffic"—a decline of 5,000,000 tons in 1916, compared with 1913—"has been arrested." The anticipated great increase of traffic under control has not yet materialised. However, having assumed control of the waterways, as of the railways, for the period of the war, the Government will be strongly urged to nationalise, and to spend money in modernising, the canals. This question of canal development will certainly be pressed as a practical issue in connection with what is called national reconstruction. The object is cheap transport. But can this be secured by canalisation? It is easy to point to the splendid inland waterways of the Continent, and to argue that what has been done abroad in this matter may be accomplished here. But it does not follow. As we have previously tried to explain, physical and economic conditions are not the same in this country as on the Continent, and the peculiarities of our transport problem should be faced, and understood before the State is pledged to the expenditure of any vast sum of money in this connection.

Briefly, it may be explained that in England and Wales we have 3,639 miles of canals; in Scotland, 183 miles; and in Ireland, 848 miles—a total of 3,822 miles for Great Britain, and 4,670 for the United Kingdom. Of the total mileage, 1,363 miles are owned by railway companies. In most cases the railway companies were obliged to take these canals as part of the price of buying off opposition to railway construction. In few cases were the railways willing purchasers. This point is worth noting when so much is said about the railways obtaining canals in order that they might strangle competition. The railway-owned canals have been kept in at least as good a condition as the others. This fact was established in evidence before the Royal Commission on Canals.

But, generally, little has been done to preserve or improve the waterways since the railway era set in in this country, whereas in some foreign countries canals and railways have been developed contemporaneously. Many of our waterways have fallen into decay. Only about half the total mileage is in regular use. Besides, these canals were originally built without any attempt at uniformity. They are of various gauges, which means that even where several systems are linked up "through navigation" is limited to the boats that can pass the smallest lock on the smallest section. And the multiplicity of ownerships means that barges travelling over the canals of several companies have had to pay several tolls, or dues. There has been no uniformity, and only in a few cases has there been any important improvements for two generations or more, whilst in many instances there has been complete neglect. But for many years now there has been an agitation for a canal revival.

In 1906 a Royal Commission was appointed to inquire into the state and working of the inland waterways. An exhaustive report was presented in 1909. The development of what is called the "Cross" scheme, which connects Midland industrial districts with the Thames, Mersey, Humber and Severn, to accommodate barges of about 100 tons capacity, was conditionally recommended. The Commissioners, without being very definite or conclusive, suggested the appointment of a National Waterways Board to take up the problem of canal development, but they were insistent upon the point that State funds or credit should only be pledged where there was a reasonable prospect of a return, direct or indirect, upon the outlay. Nothing came of the proposals; but a very influential Waterways Association was voluntarily formed, with headquarters in Birmingham, to advocate and advance the case for a great canal scheme. Before the war this Association had enlisted the support of hundreds of local authorities, trade organisations, and other representative bodies. It was comparatively easy to gain this support by presenting an array of facts and figures demonstrating the cheap carriage on Continental waterways, compared with the conditions here. The intention is to press the facts upon the attention of the Government and if possible, to secure a large sum of public money for canalisation as soon as the war is over.

Mr. Frank Impey, Secretary of the Waterways Association, contends that the proposed improvements would reduce the time in transit between Birmingham and Bristol by from 40 per cent. to 45 per cent., and the cost of freights by 25 per cent. The journey from Hull to Nottingham now occupies 57 hours, but it is argued that this could be reduced to 31 hours. From Bristol to Birmingham the time now occupies 72 hours, with transhipment in the middle, and four systems of haulage employed. In the proposed scheme the time would be reduced to 36 hours, and no transhipment. The express boats now working between London and Birmingham, employ one man to every 7 tons of cargo. Under the proposed scheme of improved canals and larger barges, each hand would be responsible for 35 tons. There would be a saving of fuel of 50 per cent., according to the calculations of the Waterways Association. The cost of carrying out the proposals was estimated at 23,500,000*l.* before the war. After the war, with the prices of practically everything enhanced much beyond pre-war levels, the cost would be much more. Before we are committed to an expenditure which might turn out to be 50,000,000*l.* on a great canal scheme, we should make, as the Royal Commissioners suggested, reasonably sure that it is a sound enterprise. There is ground for the opinion that we cannot achieve, by canalisation, at twice the cost, half the results that have been obtained in Germany, for instance.

The simple fact is that the physical and economic conditions of our country are such that we cannot have the cheap transit—that is, the low ton-mile rates for goods, either on railways or waterways—that exist on the Continent or in America. But against this we have the great advantage of short hauls—a big point which the advocates of railway and canal nationalisation seem to ignore. For

example, a rate of 1¼*d.* per ton per mile is a smaller charge on the British trader, sending his goods the usual 20 miles or 30 miles, than is the ¾*d.* of the German sending his products between 50 miles and 100 miles, or the ½*d.* even of the American, who is obliged to have his goods transported an average distance of between 400 miles and 500 miles. In any great scheme of canalisation we should find our capital expenditure out of all proportion with that of our Continental rivals; our cost of maintenance and operation, per mile and per ton, would be excessive; and these circumstances would preclude the possibility of cheap carriage, as understood by the canal advocates. The supreme point in the canal problem is that most of the Continental industrial districts which are so well served in the matter of water transport are comparatively flat, and possess large rivers which lend themselves naturally to canalisation; whereas in this country most of our industrial localities are hilly and are without rivers which are adaptable for navigation. It would be almost as reasonable to expect Switzerland to become a great shipping country, as it is to imagine that Britain can be made a first-class canal country.

In industrial Scotland, West Yorkshire, Lancashire, Durham, South Wales, and the Midland Counties, there is hardly a bit of level country or a river that is naturally navigable. Our manufacturing and mining districts mostly stand at such high altitudes that canal construction, maintenance, and navigation must always be costly and unsatisfactory, compared with the systems on the Continent. Even in the short distance between the Severn and Birmingham, there is a rise of 425 ft. There are 58 locks on the canal between Worcester and Birmingham. Between London and Birmingham there are 160 locks on our existing system, and it is admitted by the Waterways Association that in the new scheme advocated there would be 31 locks and 15 lifts. Between Hamburg and Berlin, 230 miles, there are only three locks. These are, of course, extreme cases; but, taking our country through, we have a lock for every 1½ miles of inland navigation, against a lock for 5 miles in Continental Europe. The vast difference between the physical conditions in Britain and Continental Europe may be gathered from the fact that of our navigable inland waterways of 4,053 miles, only 1,482 miles are natural river, whereas 4,392 miles are natural out of 7,006 miles in France; 5,815 miles are natural out of 7,038 miles in Germany; and 2,427 miles are natural out of 2,772 miles in Austria; whilst in Russia, 23,211 miles are natural out of 23,614 miles. Our lack of level country and of suitable rivers, the necessity for by far the most of our inland waterways to be artificial, the abnormal number of locks and lifts needed, and the constant pumping of water up to the top levels to compensate for the lockful coming down with every barge penned up or down, coupled with the time taken to get the barges through the abnormal number of locks, are conditions that combine to render really economical canalisation and cheap canal transit practically impossible in our case.

Sir John Wolfe Barry estimated, for the Royal Commission on Canals, that the cost of improving the four routes which form the "Cross," would be about £17,500,000, apart from any purchase price. Sir John figured it out that to make the "Cross" capable of accommodating barges of 100-tons capacity would cost something over 28,000*l.* per mile. Against that, German canals, which accommodate 150-ton barges, have cost only 6,000*l.* per mile to construct, whilst those which accommodate boats up to 600 tons have cost only 8,450*l.* per mile. In Northern France, where the conditions are more nearly like those of our country, the canals have cost from 25,800*l.* per mile, up to as much as 45,000*l.* per mile.

As we have pointed out before, the theory that canals are the best means available for the transport of heavy and bulky material, comparatively low in value, such as coal, for instance, was exploded many years ago by the French expert Arnollet, who showed that it was a great mistake to consider railways as suitable only, or mainly, for the carriage of passengers and goods of comparatively high value. In France, the State bears practically the whole of the expenses of the canals, and yet, in spite of this subsidisation, the barges fail to carry even coal so cheaply as the railways. For example: the cost of transport from Lens to Paris by canal is 4*s.* 7*d.* per ton, whereas by rail the cost is only 4*s.* 2*d.* per ton for a train of sixteen 40-ton wagons. But the comparison does not end there, for, whereas the barge owners pay practically nothing towards interest on the capital of the canals, or towards their upkeep—these being charges against the public—the railways are self-supporting. Moreover, the long exposure to wet, heat or frost, of the coal carried by barge is also a feature which militates against the use of the waterways for the carriage of this commodity. With fair competition between the railways and canals, the former would easily beat the latter. As it is, in that part of France, where the canals are the most up-to-date, the railways carry 75 per cent. of the total coal traffic.

In the existing crisis, Government control of our canals may eventually effect some improvements by eliminating the waste of time, the overlapping, and the delays that result from the multiplicity of managements and tolls which the bargees have hitherto had to encounter. But in view of the muddle and extravagance which usually accompany State interference, even this is doubtful. After the war, considerable improvements in canal transit might be brought about by a general linking-up and unification of the existing systems; but those who imagine that the spending of any amount of money could give us anything like the cheap and speedy inland navigation that obtains on some parts of the Continent are hugging a delusion. As pointed out by Mr. R. B. Dunwoody, in his "Inland Water Transport," whilst the average rise, or fall, on the German canals is only 1·49 ft. per mile, on our canals the average is 10·8 ft. per mile, and would, even on the proposed new system, average 8·6 ft. per mile. From this, it follows that not only would cost of construction, or re-construction, be excessive in our case, but that maintenance would also be abnormal on account of the great number of locks and lifts, besides which navigation would always be slow. In the Aire and Calder Navigation, between Hull and the West Riding of Yorkshire, we have a really up-to-date barge canal system. This owes its success mainly to the fact that there is a natural tide-water river all the way from Hull to Goole, and an unusually level tract of country from Goole to within a few miles of Leeds and Wakefield. But this is a very exceptional case. The money proposed to be spent on canalisation had much better be devoted to extending the extra tracking of our railways, and improving our highways.

PROBLEMS IN ATOMIC STRUCTURE.

AT the Royal Institution on Saturday afternoon last Sir J. J. Thomson, O.M., P.R.S., delivered the concluding lecture of his course on the above subject.

He had, he said, on the last occasion called attention to certain numerical relationships between the atomic weights, pointing out that if the numbers representing them were divided by four there was a tendency for the remainder to be either three or zero. With two exceptions, viz., beryllium and nitrogen, this rule held for all the elements up to calcium. This peculiarity had led to the suggestion that the positive part of the atom was built up in the first place of helium residues or α particles, the α particle being an atom of helium from which two electrons had been removed. In addition the nucleus contained also, he suggested, other units consisting of a system of four electrons kept together by positive charges at the centre of the unit. The number of these positive charges must be either three or four, as such a system of four negative particles could not be held together by one or two positive charges. He should denote such a unit containing three positive charges as a b particle and would call it an α particle when it contained four positive charges. This α particle with the four positive charges seemed to have a special value in the architecture of the atom. If the cores of the atoms were built of these α, α, and b particles the fact that the residue obtained on dividing the atomic weight by four was either three or zero would be accounted for. Moreover, lithium with two as its atomic number, would have one free electron in its outer ring.

He would, Sir Joseph continued, like to say a word as to the exceptions to the rule. Beryllium had an atomic weight of just over nine, giving a remainder equal to one. It was not easy in this case to apply an independent check of the atomic weight. Nitrogen, on the other hand, was widely distributed, and there should be no difficulty as to the numerical value of its atomic weight. To be quite sure, however, he had applied the positive ray method of measuring this constant. This method was independent of the chemical properties of an element and, as it happened, nitrogen was specially well suited to the process. In the positive ray photographs the lines traced by the carbon and oxygen atoms also appeared with the nitrogen line in between them. By measuring the relative deflections of these three lines the atomic weight of nitrogen was deduced in terms of the atomic weights of carbon and oxygen without the necessity of determining the constants of the apparatus. He had taken hundreds of such photographs and had measured up some of the best. These all gave nitrogen an atomic weight not differing from 14 by more than one part in 1,000. Hence there could be no doubt that nitrogen was an exception to the rule referred to and that the accepted value of the atomic weight was right. His results, moreover, disposed of another explanation of the anomaly which might have been advanced and of which a good deal was being heard nowadays in connection with other matters. It might be suggested that the apparent atomic weight of nitrogen was due to the gas, as we knew it, being a mixture of isotopes. An isotopic element was one which had chemical properties identical with another element but had a different atomic weight. As the chemical properties were identical it was not possible to separate isotopes from each other by chemical means. Hence it might be urged that nitrogen, as we knew it, was not a single substance but a mixture of two isotopes, each of which might individually obey the rule that the residue after dividing the atomic weight by four was either three or zero. Such an explanation was put out of court by the results of the positive ray determination; since with this method two isotopes would trace two different lines in the photographs.

As the atomic weight of nitrogen actually was 14, we were faced with the peculiarity that the core of the nitrogen atom must have quite different characteristics from that of the atom of phosphorus, which was the element corresponding to it in the next chemical series. The problem thus raised was an interesting one. He had not been able to get positive ray photographs of beryllium.

In Fig. 1 he had plotted down the atomic weights up to yttrium against the atomic numbers, the atomic numbers being the number which denoted the position of the element when listed in order of the atomic weights. It would be seen that the resulting curves appeared to be portions of different straight lines. Taking the first section, which included all elements up to calcium, the elements plotted very well with the exception of argon. At calcium there came a break, the new line being parallel to the first section but not a continuation of it. This section extended up to gallium at which another break was evident. A possible explanation of these breaks was that certain elements were missing so that the atomic numbers of the heavier elements were too low. There did not, however, seem room for new elements at these stages, Mendeleef's series being already complete.

As an alternative, the breaks might be due to large positive cores being unstable unless they contained more than one α particle to cement them together. On this view the atoms of the elements up to calcium would contain only one α particle. To secure stability with higher atomic weights an additional α particle was required. This sufficed up to gallium, when a third α particle had to be added to the core in order to secure stability. These α particles being constituted of four electrons held together by four positive charges were electrically neutral. The presence of an additional one would

not therefore affect the outer ring of electrons or the position of an element in Mendeleef's series. It would, however, raise the atomic weight by four units. On these lines the breaks shown in Fig. 1 would be accounted for by the supposition that at a certain stage stability required that the atom should contain two a particles in place of one, and at a later stage three a particles instead of two.

One or two peculiarities in Fig. 1 seemed to point to some phenomenon of the above kind. The atomic weight of argon appeared to be too high. It ought to come before potassium instead of after it, with an atomic weight of 36 instead of 40. This fact suggested the view that argon lying near the critical value was unstable with only one a particle in its core and accordingly had two. This addition would raise its atomic weight by four. Another point of importance in this connection was that the only known example of radio-activity in elements of small atomic weight was provided by potassium. That potassium was radio-active had been first shown by Campbell. This radio-activity might, on the view put forward above, be associated with the position of this element in the diagram, Fig. 1, where it appeared to be hovering on the verge of instability, being close to the first break where the Mendeleef series changed from the short series comprising eight elements to the long series having 16. The second break, it would be noticed, occurred in the middle of this long series at gallium. This suggested that the properties of the atom might depend not merely on the number of free electrons but also to some extent on the arrangement of the positive part, the properties being different according as the core contained an even or an odd number of the a particles. Taking the series Li, Na, K, Cu, Rb, &c., the three first elements would all, on the view put forward, have one a particle, which was an odd number. Copper in the same series would contain two a particles, which was an even number and it was not until we got to Rb with three a particles that we got back to the properties of sodium. The case was similar with the series F, Cl, Mn, and Br, so that whether a core contained an even or an odd number of the a particles might have a considerable influence on its chemical properties.

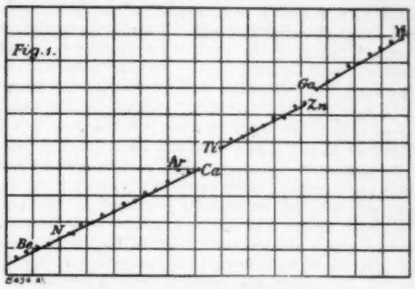
Mr. Moseley had studied the frequency of the characteristic radiation emitted by different elements when exposed to Röntgen rays. He found that if he plotted the square root of the frequency of this radiation against the atomic number of the element the resulting curves were straight lines (see Fig. 2). This was, Sir Joseph said, exactly the relationship between the two which would hold if the cores of the atoms were built up in the fashion described at the commencement of the lecture. It could be proved that, with that constitution, the highest frequency emitted would be in accordance with the following formula :

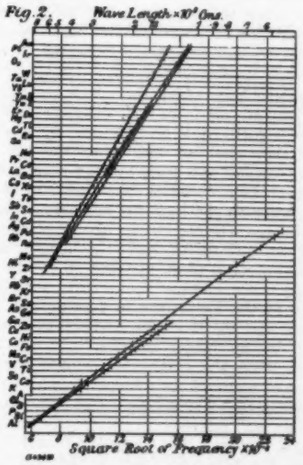
$$\text{Atomic number} - s = \sqrt{\text{Frequency}}$$

Mr. Moseley's results indicated that s was an absolute constant. On the speaker's theory the value of s depended upon the absolute number of electrons in the ring nearest the centre of the atom. If this number were constant, Moseley's result followed exactly. If the first ring were in all cases built up of electrons at the corners of a twisted cube Moseley's result would hold, but there should be a difference in s if in any case the configuration of these electrons was represented by a dodecahedron. Such a difference in the arrangement would cause a slight, but only slight, disturbance in Moseley's law, and further investigation was required.

Moseley's results had reference to vibrations of the innermost core of electrons, but some of the results observed when the electrons of the outer shell were set in vibration were sufficiently striking as to lead to the expectation that they would be capable of affording us some information as to the characteristics of this outer ring. These vibrations were excited by rays incapable of penetrating to the inner core. Thus, the lecturer showed that on bombarding different substances with soft cathode rays the glow produced was of a very characteristic kind. A noteworthy point, he said, was that quite slight changes in the chemical composition might make great differences in the colour and intensity of the glow, and he thought accordingly that a study of this phenomenon might yield a good deal of information as to the nature of the outer layer of electrons. Sir William Crookes, indeed, had applied the method to sort out rare earths, tracing thereby the results of his fractionations. The same study might also give data as to how the atoms were linked together in the molecule.

In the next place, Sir Joseph Thomson said that he would like to say a word as to the enormous importance of extreme accuracy in the determination of atomic weights. These atomic weights could be regarded roughly as whole numbers, but the interesting point lay in the small differences actually found between the atomic weights and the nearest integer. From the theoretical standpoint these differences were of enormous importance in connection with the views entertained as to the nature of gravity and as to the energy available within the atom. We regarded the fact that the





atomic weights were so nearly whole numbers as due to the atoms being built up of positive units equivalent to that of the hydrogen atom. The atom was thus built up by putting together a number of these equal units so as to form a sort of chemical compound of a very intimate kind.

Enormous labour had been spent, and special laboratories built for the express purpose of determining whether chemical combination was accompanied by a change of weight. The conclusion at present accepted was that no such change had yet been detected.

The possibility of detecting a change of this kind was more promising with radio-active bodies as so much more energy was developed in their changes than in chemical reactions. The attempt was first made at Cambridge, where the speaker had compared by pendulum experiments the ratio of mass to weight in the case of radium. The result showed that this ratio had the normal value to one part in a few thousand. A further experiment with a uranium compound gave the normal result to an accuracy of one part in 30,000 to 40,000, and quite recently Zeeman had obtained the same result with a limit of error not exceeding one part in three or four million. If any such change of weight were to be detected it would be when we came to the inner cores of the atom where the union between the constituents was far more intimate than it was in any chemical compound. Any change of weight due to the formation of this core would show itself as a difference between the atomic weight and the nearest whole number.

Looking at the small differences between the atomic weights and integers it was evident that extreme accuracy was required in order to form any reliable conclusions as to possible changes of weight consequent on the assembling together of the atomic cores. In these questions the natural unit to use was the atomic weight of hydrogen and not that of oxygen which was the basis used by chemists, and on which the atomic weight of hydrogen came out as 1.008.

Taking all the elements up to chromium (with high atomic weights differences from integral values were difficult to detect) it would be seen that in the vast majority of cases the atomic weight (on the hydrogen basis) was a little less than the nearest integer, and further that reckoned as a percentage of the atomic weight this difference was almost exactly the same. This result would naturally follow if the atoms were multiples of some standard substance. If we took oxygen as 16 (H = 1.008) the atomic weights were more nearly integral than with H = 1. In the vast majority of cases (Be. Mg. Si. and chlorine were exceptions) the atomic weight was less than the nearest integer. The most conspicuous exception was afforded by chlorine, and the speaker had accordingly examined this gas by the positive ray method and obtained thereby the normal value for the atomic weight.

The fact that with the above four exceptions the atomic weights were less than integers was from one point of view of almost critical importance. Theory indicated that changes of mass should be produced by changes of energy. There was a change of energy when chemical combinations occurred, and the corresponding change of weight could be calculated. This change in weight would be, in short, such that if it were set moving with the velocity of light its kinetic energy would be equal to the energy developed in the reaction. Calculation showed that this change in weight was too infinitesimal for measurement.

If, however, the hydrogen unit in the interior of atoms had the value 1 instead of 1.008, we had here a change of weight of nearly 1 per cent., due to energy liberated in bringing up the units together. This change in weight seemed small, but calculation showed that the energy which must have been liberated was very great. The formation of one gramme of the substance would, in fact, be responsible for the liberation of energy equal to 45,000,000 tonnes-meters.

The fact that the atomic weights of beryllium, magnesium and chlorine were more than integers indicated that energy of this order had been stored up in bringing together the units forming the cores of their atoms.

As already stated the proportion by which the atomic weight differed from an integer was the same for very many elements. This fact told one thing about how the core had been built up. Assuming the core to be built up of a particles, these particles had first to be constructed by getting together four positive charges; and the core was then built up of the units thus formed. If the greater part of the energy were due to the attractions of these different sets for each other, its amount would be proportional to the square of the number of sets. As stated, however, the energy liberated was simply proportional to the number of sets. Hence most of the work done was in forming the a particles, and the energy liberated on subsequently bringing these a particles together was but a small fraction of this.

If we could get to know the arrangement of things in the cores of the atoms we should also get light on the nature of gravity. Hence the study of the atomic weights was a matter of the greatest importance. It had therefore attracted a good deal of attention and much more was known now than 20 years ago. The speaker thought it would be desirable after determining these atomic weights by the usual chemical methods to check them by the positive ray method so as to exclude errors due to the existence of possible isotopes.

There were great openings for further research on

these matters. All, however, had had to be put aside for work of more pressing importance. These lectures had suffered accordingly, Cambridge was engaged on war work, and it had not been possible to transport to London apparatus he would otherwise have exhibited, nor had it been possible for him to give as much time to the preparation of the lectures as he should have otherwise desired.

THE BIRMINGHAM MUNITIONS AREA.

WE started this war, as we have started—and concluded—so many great enterprises, with the idea that individual effort and management would give the best results. But we had never before entered into a contest with an antagonist who had made a deep study of co-ordinated manufacture, and had at the same time reduced red tape and bureaucratic control to a minimum. It did not take many weeks to show that we were quite outclassed in our methods, and the result was that the Ministry of Munitions was soon inaugurated. Among its early proceedings was the division of the country into munition areas, in each of which there was instituted a committee of engineers and business men to advise the Ministry as to the manufacturing capabilities of the area, and the possibilities presented by the various works. No act of the Ministry has been more fruitful of good results than this, for the committees have knowledge of local needs and capabilities far beyond that to be found at Westminster, and further they can soften the necessarily harsh methods of Government control by persuasion and neighbourly advice. However patriotic a manufacturer may be it is not always pleasant to be "controlled" in a way which conflicts with his own ideas of what is best, especially when the orders come from those who are imperfectly acquainted with what he has succeeded in doing in the past, and with the difficulties that surround a change to a form of manufacture with which he is not acquainted. It is quite another matter if the directions come from his neighbours and friends who can assure him that in inflicting the change upon him they are acting in the highest interests of the country and that they will assist him by all the means in their power. The members of the committee can generally point to the sacrifices they are making themselves, and instead of imposing orders, as must necessarily be done by a central authority, can awaken a spirit of emulation and enthusiasm which rides triumphantly over difficulties.

This, at any rate, has been the experience in the Birmingham area, and there is no part of the country in which greater difficulties had to be faced. The district is a large one, including parts of Staffordshire, Shropshire, Worcester and Warwickshire, and the towns of Leek, Stoke-on-Trent, Shrewsbury, Kidderminster, Worcester, Redditch, Tamworth and Burton-on-Trent, in addition to the congeries of towns and villages known as the Black Country. There is probably no more busy manufacturing area in the world, nor one with a greater variety of trades. With some few notable exceptions, however, it did not appear a promising field for the production of munitions. It certainly could not compare in this way with the districts of the Clyde, the Tyne, and Sheffield, all of which had long been noted for the production of weapons of war. The name Birmingham connoted light trades in the main, and almost exclusively those devoted to peaceful products. Fortunately a committee was secured that understood the character of the manufacturers of the district, and of this committee, Mr. T. Harris Spencer, of Messrs. John Spencer and Co., of Wednesbury, was appointed chairman, there being joined with him Captain R. S. Hilton, vice-chairman; Mr. H. C. Atkinson, of Messrs. Benton and Stone, Limited; Mr. Edward Williams, of Messrs. H. W. Ward and Co., Limited; Mr. George Ryder, of the A.S.E.; Mr. H. E. Allen, of the Midland Railway Carriage and Wagon Works, Limited; Mr. E. Ll. Morcom, of Messrs. Belliss and Morcom, Limited, and Mr. A. H. Moseley, secretary. It was no easy task that lay before the committee. They had to transform the industries of a district without any delay, and to teach new trades to men who had grown old in crafts which had been handed down from generation to generation, and who had attained great excellence by a long process of trial and error rather than by scientific research. The Birmingham area, in spite of its great civic enterprise and its active municipal life, is essentially conservative in manufacture. It is slow to alter methods which have made its name a synonym for excellence in all parts of the world, and nothing less than a national call could have induced it to enter into new industries of which it had no experience and for which its tools were ill adapted. The task of the committee was formidable, not from any want of goodwill on the part of the manufacturers, but from their natural feeling that it was useless to endeavour to turn out highly specialised objects, of exceeding accuracy, by workmen who were quite unaccustomed to fine measurements and by tools that were unsuitable. However, the attempt was made and the result has exceeded all expectation. The Birmingham area is now a most important contributor to the needs of our army, and it is doing its full share towards securing the victory to which we are all looking with hopeful eyes. In four particulars—the tanks, the Handley-Page aeroplane, the Lewis gun, and the manufacture of T.N.T.—it is making most important contributions. In relation to all these we hold a high superiority over the Germans. The tanks are essentially British, but now we are meeting copies of them made in Germany. In the air we hold an undoubted supremacy, and our bombing planes are carrying terror into German towns which gloated over tales of the destruction of London. The Lewis gun has contributed largely to the success of our airmen, while our high explosives have relieved our men from the awful strain to which they were subject when our gunners had little beyond shrapnel with which to reply to the enemy's bombardment.

The works from which these four arms are being turned out are all new, and although they are in the Birmingham area, and are run by men of the district they are not native to the soil. They represent capital and brains rather than hereditary skill, and one's curiosity naturally turns in the first instance to see how the indigenous industries have adapted themselves to the new conditions. If there is one thing for which the Birmingham area is more eminent than another it is the art of stamping. The stranger looks with amazement at the skill of the operatives in turning out needles, jewellery, and the thousand and one fittings which are included in "fancy articles." It was natural, therefore, that the committee should direct the attention of many of their friends to what are called components, that is smaller parts of munitions which are not so well adapted for production in ordinary engineer's works. The suggestion that a silversmith should turn out fuses, or friction tubes or friction wires, or gas masks, although quite outside his experience, proved on consideration to be a reasonable proposition, for it involved principles already familiar to him and his operatives. It is a far cry from the beautiful statuettes and artistic shields of Messrs. Elkington and Co., to brass stampings for fuse bodies; shrapnel sockets and many like things. But there is, at any rate, a point of connection between the different industries, and this furnished a bridge over which the change was made. The salient feature in their new manufacture is the production of hot brass stampings. If the war has not inaugurated this industry it has, at any rate, given it an immense impetus. In dozens of works brass articles of great intricacy are being struck out hot at two or three blows which formerly were turned and milled out of solid stock at great expense and with the production of much waste. So successful is this process that Messrs. Elkington alone have an output of 200 tons weekly, and in other works the same process is pursued. Of more importance, however, than the introduction of a new process is the fact that a firm which has been filling our homes during three generations with artistic silver ware, and has shown the world that we can compete with the Italian masters of the craft, has been able to turn in a short time to the production of munitions, and to take a part in the greater struggle for the salvation of the world from the dominance of brute force.

It is a characteristic of military orders that they are given in millions, so there is no need for a firm to distribute its energies over a wide field. This was brought home to us in a tour last week through the Birmingham area. We found quite a considerable part of the works of a firm of manufacturing silversmiths, Messrs. Hukin and Heath, Limited, engaged on the production of friction wires for T. tubes. These are made of half-round wire, bent into an eye at one end to receive a lanyard, twisted together at the other end and grooved to give the necessary frictional surface. The entire manufacture is exceedingly simple, but it is not an easy matter to turn out 120,000 a week at a minimum price and with the accuracy demanded by Woolwich. To do this requires much ingenuity in the production of jigs and other devices, and much patience in training young girls to attain the necessary dexterity together with the meticulous care required for all matters connected with artillery. At the same works there are being made closing discs for primers at the rate of 200,000 a week, and very complicated angle tubes for box respirators, requiring 50 separate operations. The head of the firm said that before the war a 2-ft. rule was the finest measure their operatives used, whereas now they employed micrometers habitually. We found the same friction wires being made in the works of another silversmith, Messrs. W. J. Myatt and Co., Limited, and it was interesting to note the difference in the methods employed, showing how various minds approach the same subject on alternative roads and converge to identical ends. In the same works there are made for the French Government friction tubes, each representing 81 operations, the whole appliance being scarcely too large to hang on a watch chain, and being very largely made by stamping. Eighty thousand are turned out per week, in addition to ball-end rods and sockets to primer anvils, besides turnbuckles for aeroplanes, cigarette cases for the troops and safety razors. The number of hands employed has risen from 250 to 800, of which only 40 are employed on the original work of the firm.

There are very many other works of similar kinds about which we might write in the same strain. In some, of course, the change was not so great, for the army requires many things which are also used in peace. For instance, electricity plays an important, if a subsidiary, part in warfare, and it is not a great step from electric light and power accessories to electrical switches of other types, especially those on aeroplanes. So great is the demand for such things that one firm—Messrs. J. H. Tucker and Co., Limited—have increased their staff up 800 hands, a part, however, being engaged on fuses, while their output has been multiplied by five. Tools, of course, are needed in the army for cycles and motor cars on a scale quite unprecedented, and the "King Dick" spanner known to all wheelmen as the product of Messrs. Abingdon-Ecco, Limited, is now made in larger quantities than ever. Kits of tools of a larger size are being turned out in vastly increased quantities while large portions of the works are also engaged on fuses for trench warfare, primers, stud lockets, fuse sockets, and many other components. Even such an unlikely trade as bedstead-making has been capable of transformation to present needs, and in many works is adding its quota to the general contribution.

It would be tedious, even if it were desirable, to go through the whole list of Birmingham and Black Country trades, and show what they have done for the war. They have all borne their part, and even such remote firms as those in the Potteries which have a few lathes for constructing their own machines, or for keeping in repair machines bought from the outside, have lent their aid and have done rough turning and boring of shell, or if they were not able to do this they have surrendered their tools, which have been assembled in composite works and used to the common end. It is quite a usual experience to find old lathes doing all that they are capable of, and standing in prominent contrast to the modern tools with which they are surrounded. They are not highly efficient, and they are not capable of precision work, but in the early stages of the war they helped the general

output and they did something so save the situation when affairs were critical and to enable our men to carry on until at last the Ministry of Munitions could announce that in shell, at any rate, the pressure was relaxed and safety attained.

It is impossible to notice in detail all the small industries of the Birmingham area, and all the industries which lie outside engineering. There are very many towns, large and small, which have exerted themselves to the utmost, but the most that we can do is to select one as representative of the others. We may take Kidderminster as an example. To the general public it suggests carpets, although as a matter of fact Kidderminster carpets are mostly made in Scotland, and carpets of much higher quality, such as Wilton and Axminster, are made at Kidderminster. Very early in the war the town elected a Munitions Committee, which set to work to organise its resources, and to encourage its manufacturers to supply the needs of the Ministry of Munitions and of the War Office. There were already several engineering firms in the town, such as Messrs. Bradley and Turton and the Castle Motor Company. These firms were on a modest scale, but still they had plant which was either directly available for the manufacture of shell or was capable of adaptation. They took up the production of 4.5 H.E. shell, of machine tools, of 6-in. Newton bombs, and of ingot-melting furnaces, and they made a success of all they attempted. Of course, they needed help in the first instance. They could not all put down shell forging plant, and no one probably could carry the manufacture to the last stage. But within the limits of what was possible they rendered valuable aid to the country at the cost of much trouble and anxiety. There were other firms which could not be classed as engineers, but who had fitting shops of considerable size to attend to their own machinery. Of such, Messrs. Brunton, Limited, is an example. Their normal trade was carpet manufacturing and the spinning of worsted and woollens, but under the energetic guidance of their managing director, Mr. Cecil Brunton, they have transformed their mechanical department until now their weekly output of 4.5 shell is reckoned in thousands. We saw their plant last week, and were struck by their tools. There were scarcely any that could be called special. Many were of the ordinary jobbing variety and some were built up of odds and ends, and did not fall into any recognised category. They just showed how satisfactorily shell manufacture can be carried out by capable mechanics even if they have no special appliances. It is well known that the Ministry makes no exceptions in the matter of quality and exactitude. All the shells it accepts are perfect, and the only difference that exists between the highly organised shop and the one that may be called makeshift is in the speed of output. One might also imagine that there would be a great difference of cost, but it is well to remember that the large firms have great on-cost charges which do not exist in small shops, and which nullify to some extent the economies which arise from intensive production.

Well as Kidderminster has replied to the demand for shell, there are other and better ways in which it can work for the army. Soldiers have many wants besides weapons, such as blankets, hosiery, belts, parachute and aeroplane straps, and these can be well dealt with by firms used to spinning and weaving. New looms have been installed, new dyeing plant procured, and what are practically new, although correlated, industries introduced into Kidderminster. At the works of Messrs. Smith and Co. a new type of felt for covering water bottles is being made from worn-out blankets to which 50 per cent. of new wool is added. Blankets themselves are being made from a mixture of wool and worsted with advantage and economy.

In this article we have not dealt, except incidentally, with the great engineering firms of the Birmingham area. Those must be reserved for a future issue, and indeed justice cannot be done to them until the war is concluded. It is sufficient now to say that erection of new works and the extension of old works near Birmingham during the past eighteen months has been almost beyond belief. Hundreds of acres of green fields have, during that time, been covered with workshops which have long been filled with tools and active workers. These shops show no signs of haste or incompleteness. They are of the latest design, well lighted, comfortably heated and properly ventilated. In addition they are connected with canteens, music rooms and technical institutes. Notices are posted on the gates about clubs, games and concerts, and it is evident that the management find time to consider many questions beyond direct output. Numerous experiments are being tried under war conditions that would never have come to birth under the former competitive system. We do not for one moment suggest that these are peculiar to Birmingham, but it is quite possible that that city with its great municipal enthusiasm may develop further or faster than other areas.

In a district bristling with factories and works as does that round Birmingham, and devoting not only plant and material, but muscle, heart and soul to winning the war, it is certain that supplies for our air forces will be well represented. The manufacture of aeroplanes, however, is a very different matter from the production of shell and of fuses, which can be undertaken almost anywhere, and by almost any kind of tools. Aeroplane bodies and wings require very spacious shops or vacant land for their erection. They call for timber-working machinery, both large and small, and a great many miscellaneous appliances and processes not familiar to engineers. The engines, again, represent the last word in mechanical construction, and can only be undertaken by the aid of the most specialised tools, and in workshops in which accuracy in manufacture has long been an ideal. Consequently, although aeroplanes are being turned out in this district by hundreds per week, it is mostly in new shops, or in those containing wide spaces like the factories of the various wagon companies. One is usually met with the remark, "Eighteen months ago the grass was growing on this spot," and any one contemplating the erection of an engineering works could very profitably spend a week near Birmingham studying roofs and stanchions and crane girders, for an immense variety of patterns is to be found within a few miles. The manufacture of aeroplane fuselages and wings is primarily a carpenter's job, and the carpenters are mostly women. It is only in the giant Handley-Page machines that timbers of any size are found. In these, as in all others, every piece is standardised, and jigs are provided for each piece, so that all are cut exactly alike without thought or measurement on the part of the operative. The fuselage is built up in the main like a square lattice girder with squared timbers and wire diagonal stays. Of course, there are special parts at the pilot's and observer's seats, and for the gun mountings which involve curved methods of construction and considerable handwork. The diagonals are all provided with metal attachments, which call for great ingenuity and method in their manufacture. Stamping, punching and acetylene welding are all used in their construction, and one meets these attachments in all manner of small and unlikely shops in the Birmingham area. The tightening screws for the wire stays are required in thousands, and find employment for hundreds of girls who formerly were employed on buttons and hooks and eyes. The building-up of the wing bodies is peculiarly fascinating. The main longitudinal timbers are prepared by saws and moulding machines, as one would expect, and these carry the cross stays, which, when covered with fabric, give the wings the rounded upper surface and the flat lower surface upon which their lifting power so greatly depends. These cross stays resemble models for bow-string girders, and might have been made for demonstration purposes in a technical school. They are so light that one could hang three or four on a finger without inconvenience. They are built up by women in jigs or moulds in which there is a recess for each individual piece, and they grow rapidly as each tiny piece is put in its position, and secured by screw, nail or glue. Some sections are made first independently and clamped up for some hours for the glue to harden, and are afterwards inserted in the main structure. The peripheries of the wings are made of bent wood secured to these stays, and at one side of each there is an aileron for use in banking. Hence it comes that there are several designs of cross stays in a single wing with all the attendant complexity in manufacture.

The covering of the wings finds work for a large number of women in sewing the fabric, which must be strained tight, and in the subsequent doping. At one time this was a dangerous occupation, and needed frequent breaks with opportunities for breathing fresh air. Owing to greatly improved ventilation this is no longer necessary. The fact that amyl-acetate vapour is very heavy is taken advantage of to prevent it getting into the general atmosphere. In the latest factories large grids are put in the floor of the doping shop at frequent intervals, and these are connected to underground conduits converging on to an exhausting fan, which discharges into the air. By this means the vapour is led away before it has time to mix with the general atmosphere of the shop.

The Handley-Page machine is the Dreadnought of the Aerial Navy, in the sense that up to the present it carries the heaviest armament. Like the battleship, it needs its squadron of fast auxiliaries to protect it from similar craft belonging to the enemy, except when it can operate by night. It will carry many heavy bombs and it can release them at will, or all simultaneously if required. This sounds very formidable, but it must be remembered that a 9-in. shell weighs more than 250 lb., and that a gunner, if he has the assistance of a well-posted observer, can put shell after shell on a piece of ground much less than a cricket field. The airman is by no means so certain of his aim, unless he comes quite low, when his chances of being brought down are vastly increased. In the struggle between aircraft and anti-aircraft guns the progress is by no means on one side, and in our recent visit we found greatly improved sights, of which we must not speak in detail, which will oblige the airmen to keep to higher levels than are favourable to exact bombing. This is the old see-saw of war. A new weapon promises universal destruction, but before it is perfect a new defence has arisen, and obliges it to act from a distance, and so it comes that the carnage in a modern battle is proportionately much less than in the days of spears and arrows. The armament of the Handley-Page machine is not confined to bombs; its crew of four men have each a machine gun which can operate through a large arc, and when there is no load of bombs, 12 men can be accommodated in the fuselage, which is 62 ft. long. Large as it is, it does not look like a *voiture de luxe* for that number, but rather suggests the proverbial sardine box. There are two twelve-cylinder engines, one on each side of the fuselage between the wings. The speed, of course, is not great for an aeroplane, but it can be maintained for many hours. We are informed that there are 16,000 parts in each machine.

The reconnaissance airplane is the "destroyer" of the aerial navy. But there is not the same difference of construction between the small plane and the large one as there is between the torpedo-boat and the battleship. There is one engine instead of two, but in other respects the difference is one of scale rather than of principle. The manufacture can, naturally, be carried on in smaller shops, as there is no great spread of wings to accommodate, and all the spars and stays are lighter and even toylike. On the other hand, a multitude of scouts are wanted for each big machine, and hence the total space occupied in manufacture is far greater.

There are several other aeroplane factories in the Birmingham area, the most noticeable being those of the Austin-Motor Company, Limited, and of the Wolseley Motor, Limited. The former constitutes part of a great establishment comprising three separate works, nearly the whole of which have been erected since the war. One is devoted to aero engines and 9.2-in. shell. The second makes 8-in. shell and 4.5 howitzers, and the third, 18-pr. shell only. This plant was founded by Mr. (now Sir) Herbert Austin, and originally employed 250 hands, a number which has now extended to 20,000. A village has been built to accommodate 2,000, while 9 trains and 46 motor buses help to convey the remainder to and from their work every day. A vast aerodrome is being

constructed, and for this purpose a great hill is being cut down and used to fill a hollow, hundreds of thousands of tons of earth being in course of removal by steam excavators. When this is complete the machines will be flown away to their destinations without use of the railways. The aeroplanes turned out are of the fighting type, and although it is undesirable to say what is the weekly production, it is clear from the size of the works that it is very great, while the number of engines is larger than that of the planes, and part of the production is utilised elsewhere.

The Wolseley works have been greatly enlarged since the war and extensive shops have been erected on a neighbouring site for the construction of aeroplanes, among other things. The first order given out by the Government in 1914 was for 50 engines, but they were unable to supply drawings or a complete specimen. The firm now supply each week engines, either complete or in the form of spares, to the aggregate of many thousand horse-power. It is useless to attempt to describe the manufacture without publishing drawings, which, of course, is prohibited, but it may at least be said that more splendid workmanship is scarcely conceivable. The engine journals are ground with the finest accuracy, and the bearings are reamed out in place, the two going together absolutely without bedding or scraping, and all the other parts being equally accurate. Many of these engines go elsewhere to be fitted to planes, but a large number are mounted on planes constructed in the works. It is useless to refer to the details of manufacture of these machines, for probably in no munition of war is there more similarity of constructive devices than in aeroplanes; there is far more diversity in shell manufacture, although at the first sight there appears to be less scope there.

Prominent among the Coventry firms is the Daimler Company, Limited, which was founded in 1896 and made a great reputation by its motor vehicles. Three days after the outbreak of war the company undertook the manufacture of aero engines, and has since built an immense factory for engines and aeroplanes at some little distance from its former premises. Much new machinery has been laid down, and large additions made to labour, which, however, bear only a small proportion to the increase of production. Specially designed tools and perfect organisation have resulted in intensive production to a degree undreamed of before the war. The Daimler works have become an asset of great national value. Not far distant are the works of the Siddeley-Deasy Motor Car Company, which formerly made motor vehicles, but not the motors themselves. Since the war their works have been extended to ten times their original size, and the number of their employees in even greater proportion. A further large extension is being made to their works, and it is intended to increase the output of aeroplanes not only in quantity but also in the actual size of the craft. At the time of our visit there were engines in the test shop developing 7,500 h.p., and it is hoped to raise this figure to 12,500 h.p. The aircraft built are of the reconnaissance type at present, but, as stated, large craft are in contemplation.

There are three or four other firms engaged in aero-engine building and aircraft manufacture at Coventry, but it would only be repetition to go through the list. We feel, as it is, that this is a bald and unsatisfying account of what is being done, but it is as full as it is permissible to make at this stage of the war. Indeed, our object is not to give details of construction or statistics of output, but to indicate broadly the immense effort which is being made in the Midlands to achieve an overwhelming supremacy in the air. It must be remembered that we are dealing only with a small part of the country, and that other districts are also straining their energies in the same cause. The output is stupendous, but it is still unsatisfactory. A war is like a race; it is only the one that comes in first that wins, and there is neither prize nor glory for a good second. No single variety of munitions offer greater promise of aid to ourselves and discouragement to the enemy than aircraft, but it is not until the sky has been swept clear of German airmen that we can rest satisfied. To attain that end we need more planes and greater variety of planes, swifter planes, larger planes, and more agile planes than our opponents. The progress of the last twelve months has been immense, and is cause for congratulation, but it must not be allowed to subside into satisfaction. There is yet much to be done. There is room for simplification and for the reduction of types. There are still too many engines, and we are far from the five or six designs promised as a maximum by the Ministry of Munitions, and which will indeed be difficult to attain, seeing the immense number of jigs and gauges that will be needed and the re-education of many unskilled hands. However, a commencement has been made and it should not be difficult at once to weed out many types which are only made in small quantities.

(To be continued.)

NOTE.

An American Engineering Council.

The United States has suffered like ourselves from the neglect of engineers to play that part in public affairs which should be the natural concomitant of their exceptional knowledge of economic and social conditions. Neither here nor in America has it been the custom for those in authority to seek the opinion of our great technical societies on such questions as, for example, the nationalisation of railways or the organization of electrical light and power distribution. Had the government been guided by engineers, Mr. Chamberlain's disastrous Act of 1882 would have been most materially modified before inscription on the statute book. Similar mistakes have been made in America. Indeed, Mr. Waddell, the well-known bridge engineer, has stated that in a certain case the position of County Engineer has been filled by a lawyer on the plea that a politician was necessary for the job. One effect of the war has been to enhance the importance of the engineer in the eyes of the community at large, and the time is therefore opportune for an endeavour to ensure that important industrial and economic changes shall not be effected in the future without at least ascertaining the views of the engineering profession. Partly to this end and partly to help in the war an Engineering Council was formed in America. The council consists of 24 representatives appointed respectively by the American Society of Civil Engineers, the American Society of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. These four societies have an aggregate membership of 33,000. The present chairman of the council is Mr. J. P. Channing, whilst Mr. A. D. Flinn is the secretary. Amongst the first steps taken by the council was the appointment of a Patents Committee to investigate reforms in the patent laws and in patent litigation. One principal aim of the council is to establish closer connection between the engineers and the general public. This is an important but an undoubtedly difficult task, as the methods of the lawyer and politician are particularly repugnant to the engineering type of mind which has, from the necessity of the case, to work mainly from the particular to the general instead of by logical deduction from some plausible but possibly quite inadequate or inaccurate generalisation. The council has already been of immense service to the United States Government in recommending suitable men for positions in the departments concerned in war operations. Here it will be remembered there was an enormous wastage of competent men. Technical appointments were filled by our own departments with men drawn from practically any other source than the engineering profession, whilst engineers of high qualifications were rejected. Many of them, after this rebuff, enlisted as privates. Indeed, the reluctance of the departments in the early days of the war to accept the services of qualified engineers went far to engender the suspicion that the officials realising their defects were particularly anxious to exclude competent outsiders from the official fold. The United States Engineering Council has evidently done much to prevent this unfortunate precedent being repeated on the other side of the Atlantic.

INDUSTRIAL NOTES.

The Controller of the Foreign Trade Department has issued a further list of firms of enemy nationality with whom trading is prohibited. Copies can be obtained from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

It is gratifying to note that in spite of the adverse ballot the "comb-out" in the mining trade is not to be resisted. The figures were: For the comb-out, 221,152; against, 250,722; majority against, 29,570. At the delegate meeting on Friday last the following resolution was passed unanimously: "That in view of the ballot not showing a two-thirds majority we recommend the conference to advise the men not to resist the taking of 50,000 men from the mines for the army."

The Board of Trade announces that the shortage of coal supplies and transport and the necessity for further economies in the consumption of coal-gas have compelled the Board of Trade to reconsider the position with regard to the use of gas in substitution for petrol in motor vehicles. While it is not proposed to withdraw nor to invalidate permits which have already been issued it is regretted that no further gas permits can be granted, except for public utility services operating north of the southern boundary of Durham and Westmoreland.

Sir Guy Granet having undertaken, at the request of His Majesty's Government, to visit the United States in connection with food and transportation problems, has resigned his appointment as Director-General of Movements and Railways and his membership of the Army Council. The Secretary of State for War has appointed Sir Sam Fay, Director of Movements, to be Director-General of Movements and Railways in succession to Sir Guy Granet, with a seat on the Army Council.

The following are some recent decisions given by the Committee on Production and the Special Arbitration Tribunal on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given:—Aircraft workers (semi-skilled and unskilled grades): The committee approved an arrangement under which plain time workers in federated establishments wholly engaged in manufacture of aircraft or aircraft parts have received a bonus of 12½ per cent. on earnings. Welded tube trade (South Staffordshire): The men concerned, who are piece workers, are to receive a bonus of 7½ per cent. on earnings from first pay in January, 1918. Increased payments granted for overtime. Skilled aircraft woodworkers: Skilled woodworkers employed in establishments engaged in manufacture or repair of aeroplanes or seaplanes, directly on such manufacture or repair, being handicraftsmen or general woodcutting machinists who have been working four years on woodcutting machines are to receive, in the case of plain time workers, a bonus of 12½ per cent. on earnings and, in the case of piece workers and men working at augmented time rates fixed in lieu of piece rates or by reference to results or to output of work, a bonus of 7½ per cent. on earnings (excluding travelling time, outworking and similar allowances) from January 1, 1918.

Under the Skilled Aircraft Woodworkers' Wages Order, 1918, skilled aircraft woodworkers became entitled to the minimum or standard district rate of either cabinet-makers or coach-makers, or house carpenters and joiners, whichever may have been the highest in force in each district on November 1, 1917, provided that in no case should the minimum rate in any district be less than 1*s.* an hour. Skilled woodworkers within the meaning of the Order employed in aircraft establishments (which expression includes any manufacturing establishment engaged wholly on the manufacture or repair of aeroplanes or seaplanes, or of components or parts thereof, and any workshops belonging to a composite establishment in which such work is exclusively carried on) are to receive an advance of 5*s.* a week from first pay in December, 1917. Having regard to the diversity which exists in respect of wages in establishments other than those indicated above, the Committee on Production make no general order as to an advance of wages to men employed on aircraft work alongside other work in such other establishments. Any necessary adjustments required in these establishments are to be discussed by the parties concerned.

What appears to be a new move in trade unionism has been inaugurated by the Dyers' Union. The complaint in the past has been that non-society men undercut wages, but the Amalgamated Society of

Dyers, Bleachers and Finishers, in connection with the Perth dyers' application for a further increase of wages, have issued a circular stating that the union intends to take action to debar non-unionists from participating in the new increase now being negotiated for.

A strike has occurred at Leeds shell factories owing to the dismissal of four men for refusing to undertake some work unless some nearby running shafting were screened. The Board of Control inspected the shafting and decided that it occasioned no danger, and the work was done by four other millwrights. An offer was made to have the whole circumstances independently investigated if the men would resume work meantime. The men, however, decided last Saturday not to consider matters further till Tuesday, and it is possible that a deciding factor has been the temptation to take a longish holiday. We do not know what the working hours are at Leeds, but many competent engineers employed by the Munitions Ministry are strongly of the opinion that in many districts factory hours are too long for maximum production, and this point should be borne in mind where strikes appear to have originated on obviously trivial points. In some cases at any rate these are the occasion rather than the cause of the stoppage.

The big steel combine to be effected by the amalgamation of the undertakings of the Workington Iron and Steel Company, Peech and Tozer, Samuel Fox and Co., and the Frodingham Iron and Steel Company, has now received the consent of the Treasury. The loan capital will amount to 2¼ millions, and the share capital to 7,680,000*l.*, making a total capital involved of over 10,000,000*l.*

At the recent annual meeting of Muntz's Metal Company, Mr. A. H. Wiggin stated that the workmen and the Treasury were each receiving from the total undertakings of the company seven times as much as the shareholders had done.

On Monday last the annual meeting of the Midland Electric Power Corporation was held at Liverpool. The chairman stated that some 53,000*l.* had been advanced by the Ministry of Munitions for the provision of the new plant required to meet the increased demands for power. This increase was continuing, applications being to hand for some 10,000 additional horse-power. This, he said, would necessitate further extensions of the plant.

Speaking at a meeting of the Manchester Statistical Society, on the 13th inst., Sir Hugh Bell defined capital as the result of skill and abstinence applied to production, in which it was an indispensable element. Any proposal for the abolition of capital by its allotment equally among all individuals he dismissed as impossible, for within 24 hours inequalities would begin to reign again. He estimated that 75 per cent. of the total sale value of commodities went to pay the persons engaged on production, and that after the various outgoings had been met there was only 10 per cent. over which the owners of capital had control. Before it could be employed capital needed adequate remuneration; without it output would decrease and the labour market be depressed. To meet a population growing at the rate of 1 per cent. per annum—which meant 80,000 additional males seeking employment every year—well on to 20,000,000*l.* of capital must be forthcoming. It was clearly to the interest of the class for which they chiefly cared that this fund should be abundantly supplied. If output was increased by more efficient methods the share of labour and brains would rise correspondingly. Greater efficiency was the only direction in which a solution of the problem could be sought. Not only labour but capital also had to be convinced of this truth, and that could best be done by taking those interested into complete confidence. Knowledge on both sides of the circumstances under which production took place would tend to bring about equitable division of the advantages of efficient capital. If these indispensable adjustments could be arrived at by better distribution of the ownership of capital no patriotic citizen should object. What was to be feared was that in the process we might find the thing to be distributed had disappeared, and that the wealth it was hoped to partition had ceased to exist. Mr. Henderson, said Sir Hugh Bell, appeared to think it possible to go on taxing to extinction all large incomes, and still leave them to be taxed. Those who agreed with him would have a rude awakening when they found the source on which they confidently relied for the 1,000,000,000*l.* a year, which was Mr. Henderson's estimate of the future Budget, had disappeared. When the war ended the thing most to be desired was the rapid restoration of the useful productive power of the world, and for this capital in great masses would be needed. The disadvantages of confiscation was that you could only confiscate once. It was not from capital engaged in industry, added Sir Hugh, that one could hope to get much more. If the Labour Party's policy depended on taking surplus wealth, as Mr. Henderson seemed to contemplate, it was not unlikely that the grimmest fears might be realised and a period of the direst calamity await this country.

PATENTS AND DESIGNS ACT AND TRADE MARKS ACT.—The President of the Board of Trade, with the Parliamentary Secretary and the Comptroller of the Patent Office in attendance, received on Tuesday, the 12th inst., at the Board of Trade, a large and important deputation organised by the London Chamber of Commerce for the purpose of making representations to the President concerning the new Bills to amend the Patents and Designs Act, 1907, and the Trade Marks Act, 1905, which were introduced in the last session of Parliament.

MANCHESTER ASSOCIATION OF ENGINEERS.—The annual meeting of the Manchester Association of Engineers was held on Saturday last, the 23rd inst., Mr. Jos. Butterworth, of Messrs. Lancaster and Tonge, being elected president for the year. From the annual report of the council, read by the secretary (Mr. Frank Hazelton), it appeared that at date there were 706 members on the roll and a cash balance to the credit of the association of 6,735*l.* A cordial vote of thanks was passed to the retiring president, Mr. J. P. Bedson. Subsequently an interesting paper on "Machine Forging" was read by Mr. D. M. Caird.

INCREASE IN PRICE OF COAL FOR DENMARK.—The Controller of Coal Mines has issued a direction which will have the effect of increasing the price payable by Danish buyers for cargoes of coal, coke-oven coke and patent fuel for export to Denmark, the shipment of which is commenced on or after Monday, March 25, by 10 kroner per ton. Sellers are required to notify their customers in Denmark of the increased charge. This will be collected by the accredited agent of H.M. Government in Copenhagen, and will involve no difference in the present price arrangements between collieries and exporters. The direction does not affect shipments under contracts made with Danish buyers before October 15 last.

GOODS TRAFFIC IN THE UNITED STATES.—The average load carried by each freight car on the Pennsylvania Railroad's Eastern lines in December, 1917, was 37.23 tons, as compared with 31.70 tons in the corresponding month of the previous year, or an increase of 5½ tons per car. Efforts to increase car loading on the Pennsylvania Railroad have been carried on for many years, but have been conducted in a systematic way since the early part of 1916, when this work was placed in charge of a special department under the jurisdiction of the superintendent of stations and transfers. In 1915 the average load carried per car was less than 29 tons. The increase since that time has amounted to more than 8 tons per car, or approximately 30 per cent. As there are 164,000 freight cars on the Pennsylvania Railroad lines east of Pittsburg and Erie, this increase in the average loading has been equivalent to the addition of 49,000 cars to the equipment available for the service of the public.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—A meeting was held under the auspices of the above Institution on Saturday, March 2, 1918, at the Philosophical Hall, Leeds, under the presidency of Colonel E. Kitson Clark, to inaugurate a local centre of the Institution. About 70 of the leading locomotive and carriage engineers of the district were present. They included representatives from Leeds, Sheffield, Darlington, Goole, York, Lowmoor and Doncaster. The Locomotive and Carriage Departments of the Lancashire and Yorkshire, Great Northern and North-Eastern Railways were well represented, as also were the large locomotive, carriage and wagon manufacturers. Mr. H. N. Gresley, chief locomotive engineer of the Great Northern Railway, was elected chairman; Colonel Kitson Clark, of Messrs. Kitsons, Airedale Foundry, Leeds, vice-chairman. Mr. A. T. Houldcroft, of the Leeds Forge Company, was appointed hon. secretary, and communications for membership of the centre should be addressed to him.

THE BRITISH ASSOCIATION.—Members of the British Association will regret to learn that this year's meeting, planned for Cardiff, has again had to be cancelled. There will thus be a break of two years in the, so far uninterrupted sequence of meetings since 1831, assuming that the meetings be resumed in 1919. The Local Committee at Cardiff has reluctantly had to inform the council of the association, that they would not be able to make suitable arrangements for a successful meeting, and the council, of course, felt that it would be at least as difficult to arrange for a Cardiff meeting as it had last year been to make preparations for the Bournemouth meeting. Thus all the arrangements remain in a further state of suspension. Sir Arthur Evans, who had presided at Newcastle in 1916, remains president for another year, and the Hon. Sir Charles Parsons president-elect for another year; further arrangements will be discussed at a general committee meeting to be held early in July, when sectional committee reports will also come up. It is sincerely to be hoped that the British Association will reassemble as soon as the conditions permit; science has received a powerful stimulus in these days, and the British Association will help to direct that movement into proper channels.

CONCRETE COTTAGES.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent "Britisher" hardly appears to be writing in the spirit of fair play usually associated with that name, but rather in the very bad temper sometimes produced by "colds, sciatica, lumbago and other maladies" which, he says, are caused by "existing" in the concrete building. He says he has had "to exist in one of these concrete *structures* for some three years" and that "the *buildings* are cold, very damp, and the atmosphere foul to a degree. The latter probably due to the gases given off by the setting material." If "Britisher" means to imply that the buildings and structures to which he refers are cottages or houses designed by a competent architect as dwellings, and for no other purpose, we shall be very glad to send an expert, at our own expense, to survey same, if he will kindly favour us with the address, and if he fears libel or other action, from his landlord, or others, we would also undertake to treat all information as strictly confidential.

A careful reading of "Britisher's" letter confirms our first impression, namely, that the "buildings and structures" to which he refers are for industrial purposes, and in that case the coldness, the condensation, the foul atmosphere, are probably due to the nature of the trade carried on, or to insufficient warming and ventilation; indeed as "Britisher" has had to insert further ventilators, the latter point will probably be conceded.

We don't want to hurt "Britisher's" already ruffled feelings, and indeed we are really very sorry for the unfortunate plight to which concrete buildings have reduced him, but he is really talking a little wildly when he alludes to gases given off by concrete in setting; concrete does not behave in this ill-considered way, and the chemical action which takes place in setting, results merely in the formation of insoluble crystals through the action of water, no gases being given off.

The building of concrete houses is a recognised industry in the States; it will become a recognised industry in England before many years are out, but there will always be enough houses of brick or stone for "Britisher" to choose from.

A cubic yard of brickwork cost, before the war, about 2*l.*, and a cubic yard of reinforced concrete about 4*l.*, but the cubic yard of concrete is equivalent in strength to three cubic yards of brick, when used as walling, hence the cost of concrete is only two-thirds that of brick. The nation has to build 300,000 cottages immediately after the war, and it is proposed that it should grant a subsidy of 100*l.* per cottage in order to enable local authorities to build without loss to themselves. If a cottage costs 300*l.* in brick and 200*l.* in concrete, as the calculation above would indicate, the saving is just 100*l.* per cottage or the amount of the proposed subsidy. The cottages would be warm, dry, durable, and non-verminous, and the saving to the nation 30,000,000*l.*, which is rather a big sum to be imperilled by "Britisher's" lumbago!

Many Britishers, besides your correspondent, receive new ideas slowly and with hostility, especially if these ideas arise in a foreign country; the war is changing this attitude however, and it is probable that the methods of house building, which have hardly progressed at all for centuries, will be very considerably revised after the war.

Yours faithfully,
TRENT CONCRETE LIMITED, E. F. S.,
Nottingham, March 18, 1918. Chief Engineer.

THE MEASUREMENT OF CURRENT IN ELECTRICAL IGNITION SPARK CIRCUITS.

TO THE EDITOR OF ENGINEERING.

SIR,—As Mr. Morgan has shifted his ground from the point at which I took issue with him, *i.e.*, on the correct interpretation of the effect produced on the low and high-frequency components of the current, by the magnitude of the resistance used in his instrument, no further discussion on this matter would seem profitable. As to his seeming belief—that I am so alive to the great complexity of the magneto spark current that I doubt the possibility of anyone being able to make a useful measurement—I hardly think anybody else reading my two letters will read that belief into them. There are quite sound and reliable methods by which the various components of the spark current can be sorted out, and methods about which there need be no misinterpretation. To go into these matters now would take too much space, but I hope to do so in the near future.

Yours faithfully,
G. E. BAIRSTO, D.Sc.
Fellowes-road, South Farnborough,
March 18, 1918.

"LA TECHNIQUE MODERNE."—We welcome our French contemporary *La Technique Moderne*, which now appears again. The first number of the tenth year of publication is dated January, 1918. It ceased to appear on August 1, 1914, the promoters, editors, and the whole staff having been mobilised as soon as Germany started the war. Notwithstanding the difficulties which still surround the publication of a journal, considering also the most important part which industry now plays in the war, the promoters decided to take up their work afresh and, for the commencement at all events, to keep their readers posted on facts; they will deal with theoretical problems only so far as they serve as a basis for applications in actual practice. We wish the journal the same success which it achieved in the past.

THE ROYAL METEOROLOGICAL SOCIETY.

At the meeting of the Royal Meteorological Society, held at Caxton Hall, Westminster, on Wednesday, the 20th inst., Sir Napier Shaw, F.R.S., president, in the chair, Dr. J. S. Owens, A.M.Inst.C.E., delivered a lecture on "*The Measurement of Atmospheric Pollution.*"

Dr. Owens dealt with the need for exact measurements of suspended impurities in the air. He explained the work undertaken by the Advisory Committee on Atmospheric Pollution in this connection, and the methods used, and gave some of the results obtained during the last four years. He said that the era when a harmless gas like carbon dioxide was taken as a measure of impurity was rapidly giving way to a recognition that the really important thing to measure was suspended dust and dirt. It was shown that the latter connoted great waste of human life and also of fuel, light and other important necessities.

As showing the kind of air city dwellers were sometimes forced to breathe, he gave figures for deposit from the air for one year, April to March, at the following places :—

	Tons per Sq. Mile.
Oldham, 1915–16	950
Manchester, 1915–16	635
London, 1915–16	453
Sheffield, 1914–15	395
Malvern Wells, 1915–16	56

He stated that there was evidence of a general reduction of atmospheric impurity during the winter of 1916–17, as compared with the preceding one, probably due to reduced consumption of raw coal.

An account of the research work of the Advisory Committee relating to methods of measurement was also given. In conclusion, mention was made of certain problems awaiting solution, such as relation of impurity to wind and distance from source, also to incidence of disease. Does smoke in the air reduce or increase the number of bacteria ? What is the vertical distribution of suspended matter ? What is the selective power of rain or snow in bringing down impurity ? The lecture was illustrated by lantern slides.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The most notable feature at the moment in connection with the steel-making industry is the strenuous endeavour being made to get the maximum production from the mills. No cessation of Government demands can be expected meantime, and everything available is so quickly absorbed that again the necessity of bringing into force some system which would permit of the ordinary mercantile consumer, both at home and abroad, receiving at least a proportion of his requirements, is claiming some considerable attention. The local superintendent of the Admiralty who supervises all the Government work has a busy time, for large quantities of steel are being consumed by the Clyde shipbuilders.

Malleable Iron Trade.—No suggestion of slackness can be spoken of in connection with the malleable iron trade. Makers are at present chiefly engaged upon work of national importance, the urgency of which is beyond dispute, and both the iron and steel departments are fully employed. While prices remain steady at the level of the past few weeks there is every expectation that an advance may take place shortly to meet the higher oncost rates now ruling. For export marked bars are being done at anything from 16*l.* 5*s.* to 16*l.* 10*s.* per ton.

Scotch Pig-Iron Trade.—In the pig-iron industry, despite many unavoidable drawbacks, matters are running particularly smoothly. The demands on Government account continue on so extensive a scale that practically nothing but certificated work is being considered, and, so far as export is concerned, nothing is really being attempted at all. A certain shortage of some brands has still to be contended with. Values are unchanged, but here also a stiffening up is expected very shortly for export sales.

QUEENSLAND ARTESIAN WATER SUPPLY.—The Queensland State hydraulic engineer states that the total number of bores in Queensland, according to the records of the department, is 2,980. Of these 1,132 are flowing bores, 1,035 are bores pumping supplies, and 813 are in progress, abandoned, or uncertain. Government bores number 233, those owned by local authorities 45, and those privately owned 2,702. The estimated continuous yield from the flowing bores is 433,061,560 gallons per day, which would cover about 908 sq. miles of country to a depth of 1 ft. if spread equally over that area. There are now 126 bores marked as having ceased to flow, or over 11 per cent. of the total number of bores originally flowing. The first bore noted as having ceased to flow was Saltern Creek No. 1, in December, 1895. The deepest bore is Bimerah No. 3, 5,045 ft. The department has intimation, however, of a bore in the Blackall district which is said to have reached 5,400 ft. below the surface, but the reliable records in that case are not yet available. The hottest bore water is at Elderslie, 210 deg. F. This bore is also noted for having struck the largest supply at a depth of 4,500 ft., originally estimated at 900,000 gallons a day. The Elderslie bore is about 40 miles from Winton. Officially the view is held that the subterranean supply is diminishing; the amount now being drawn off by the bores is greater than the amount being added through the source of replenishment.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Colliery Progress in South Yorkshire.—Most of the benefits which have accrued to the South Yorkshire coalowners as the result of the secretaryship being in the able and practical hands of Mr. Parker Rhodes, were mentioned at the annual meeting, when the members made presentations to that esteemed official in appreciation of his valued services. Mr. Parker Rhodes' tenure of office has persisted since the very inception of the association thirty years ago. The intervening period has seen considerable developments within the activities of the association which have had great commercial significance. When the organisation was inaugurated in 1884, largely through the instrumentality of Mr. Parker Rhodes, its membership embraced 13 colliery companies, with a total yearly output of 6,250,000 tons. The association now comprises much the larger proportion of the South Yorkshire collieries, yielding together more than 25,000,000 tons each year.

Exports of Pig-Iron.—At a meeting of the Sheffield Society of Engineers and Metallurgists last night, Mr. H. S. Jackson, of Middlesbrough, pointed out that from the Cleveland district 730,000 tons of pig-iron were exported to foreign countries in 1913, while from the same district, in the same period, we only exported in manufactured iron and steel, 580,000 tons.

Iron and Steel.—There is every reason to believe that the relaxation which has shown itself in the conditions of the open-hearth and crucible steel sections will become yet more marked. Several factors have contributed to the cause of this easier state of things. The discontinuance of the Russian demands has lessened by a considerable amount the quantities asked for in munition centres, fewer exports and the decreased purchases of tool steel in France have all gone in a substantial way to relieve the calls which were being made on output. Notwithstanding these facts, however, the producing capacity of the trade has been continually on the up grade. Greater supplies may yet be asked for for aircraft and shipbuilding purposes, but these two sources alone will not completely balance the falling-off in orders from other departments. In some quarters it is felt that the Government should come to the assistance of producers and remove the restrictions which they have placed on the export market, as it is felt that this is a channel through which desirable orders would undoubtedly come. The paucity of railway wagons is not, naturally, improving the position in regard to short supplies of pig-iron and scrap. Ample supplies of billets are reaching the rolling mills, which are being kept markedly active on aircraft steel. Fresh Government contracts which have been made, include portable boilers, bolts and nuts, pumps, cooking ranges and stoves, razors, horse and mule shoes, constructional steel and tinware.

South Yorkshire Coal Trade.—The conditions obtaining in the coal trade have rendered it necessary in many cases for reserve stocks to be increasingly drawn upon. On the eve of the holidays, a big demand for manufacturing fuels is evidencing itself, and in consequence, it is more and more difficult to obtain full supplies. Gas fuels, too, are firmly sought after. Contracts are in many cases considerably behind, and notwithstanding the lengthening days which usually bring a curtailment in the demands from works, the daily requirements show no appreciable decline. The advent of summer-time, however, should have an immediate effect on household demands. Export conditions are practically unchanged, inland quotations are held at maximum rates, and slacks form a very strong market, particularly the higher grades. Quotations :—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*, per ton at the pit.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—For the time being business in Cleveland pig-iron is quiet. There is a continuously heavy demand for all descriptions, and full maximum prices are freely paid for any iron available. Deliveries, however, are somewhat disappointing, and as this month's distributions of foundry qualities, under the allocation system, will fall below needs owing to difficulty of transport, makers' stocks of Cleveland pig-iron are stated to be accumulating rather rapidly. This month's shipments to France and Italy are not coming up to expectation. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities stand at 114*s.* and No. 1 is 119*s.*

Hematite Iron.—Better accounts are given of the East Coast hematite department, and it is gratifying to hear of prospects of enlargement of hematite production. The very careful distribution is still under strict official supervision, but home customers are receiving regular supplies adequate to essential needs, and the quantities of iron available for despatch to our Allies are a little larger. For home consumption, Nos. 1, 2 and 3 are 122*s.* 6*d.*, and for export to France and Italy the quotation is 147*s.* 6*d.*

Coke.—The very ample supply of coke has no apparent detrimental effect on prices. Home demand keeps on a good scale, and the market is brisk, but foreign business is only quiet. Medium blast-furnace quality is 33*s.* at the ovens, low phosphorus kind 35*s.* 6*d.* at the ovens, and foundry description 38*s.* for home use. For export, both furnace and foundry coke stand at 45*s.* f.o.b., and gas-house product ranges from 38*s.* to 40*s.* f.o.b.

Manufactured Iron and Steel.—Pressure for delivery of finished iron and steel for Government purposes and for the shipyards is steady. The huge output is well maintained, and the new system of distribution is understood to be working quite smoothly and well Prices are very stiff. The following are among the principal market quotations to home customers :—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.* Export prices are not fixed, but they may be given approximately at 2*l.* to 3*l.* above home quotations.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Tuesday.

The Local Markets.—Colliery salesmen representing Admiralty collieries have reported fairly favourable stems this week, and are looking forward with an unusual degree of confidence to a full week's work. All pits, however, have not been affected by the improved position and reports from the Monmouthshire coalfield indicate irregular work. Best steams, including drys, have been the best markets; bituminous coals are in abundant supply, and the weakness of throughs is as great as ever. Smalls are a glut, except those suitable for coking purposes, and for them the demand is very active. The pit wood and iron ore positions are unchanged. Exporters have been instructed to comply with the recent decision of the meeting in London and refuse to pay the brokerage to the colliery owners except under protest. Members have been interested chiefly to-day in the annual meeting of the Chamber of Commerce. Sir Thomas Watson's long association with the Chamber has been memorable by his conduct as president. The Chamber never had a more painstaking or more capable head; he has given that body a larger measure of authority on commercial questions than it possessed previously; and his speeches have been particularly notable for their grip and eloquence. Mr. T. J. Callagahn, who succeeds him, has been no less active in connection with coal export trade questions than Sir Thomas, and his long experience as vice-chairman of the Central Executive will be of incalculable service to the trade during his period of office. Business has now been almost completely arranged for the holiday period.

Newport.—With the Easter holidays near, the outlook is a little more favourable than has been the case during the last few months. Most of the collieries are at work and there is a good inland demand.

Prevention of Illegal Stoppages.—At a meeting of the Welsh Coal Board held at Cardiff to-day, an agreement was signed by both sides of the board under which a Joint Sub-Committee of seven from each side was set up to expedite the investigation and settlement of disputes. This committee will meet once a week, and each side undertakes not to give any support to stoppages of collieries over disputes until opportunities have been given to the committee to deal with the matters at issue. The question arose, in the first instance, owing to the owners having issued summonses against workmen at a number of collieries for breach of contract. The owners had complained repeatedly at meetings of the board as to illegal stoppages on the part of the men, and at one of these meetings the workmen's representatives urged that the summonses which had been issued should be withdrawn. The owners could not agree to this, as prosecution was their only legal remedy against illegal stoppages. The workmen's representatives suggested that some improved machinery might be devised for dealing with disputes, in order to prevent what they considered to be unnecessary delays which occurred under the existing arrangements. The owners' representatives concurred with this suggestion, and the agreement which was signed to-day is the outcome of the deliberations which ensued.

BASLE INDUSTRIAL FAIR.—The second national industrial fair is to be held at Basle from April 15 to 30. Only Swiss firms are allowed to exhibit and the sample products exhibited have all to be manufactured in Switzerland.

RESTRICTIONS IN THE USE OF GAS AND ELECTRICITY: —All communications on the subject of the restrictions in the use of gas and electricity should be addressed to Mr. Garnham Roper, C.B., Assistant Secretary, Board of Trade, 7, Whitehall Gardens, London, S.W. 1.

"LUCERO," A NEW ALLOY.—A new alloy, claimed to be a substitute for German silver, but having unusual properties, is known as "Lucero," says *The Iron Age*, New York. It is an alloy of copper and nickel, and is stated to be permanent, non-corrosive and capable of withstanding higher temperatures than German silver. It does not contain zinc as does German silver. It has a specific resistance of 200 ohms. per mile foot, with a temperature coefficient of 0.001 deg. F. It is made by the Electrical Alloy Company, 135, Broadway, New York, with works at Morristown, N.J.

CASTINGS OF ADMIRALTY BRONZE.

*An Investigation on Unsound Castings of Admiralty Bronze (88 : 10 : 2) : Its Cause and the Remedy.**

By PROFESSOR H. C. H. CARPENTER, M.A., A.R.S.M. (President), and MISS C. F. ELAM.

IN a recent publication of the American Bureau of Standards,† entitled "Standard Test Specimens of Zinc Bronze," dealing entirely with a bronze of the composition 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc, the authors, Karr and Rawdon, have attempted a complete investigation of the mechanical properties of this alloy, as influenced by the methods of casting and heat treatment, so as to arrive at a standard method for its manufacture. They have come to the conclusion that the casting temperature has the greatest effect on the qualities of the material. This applies to all forms of castings, whether sand or chill. The temperature affects the rate of cooling and therefore the crystalline structure, the presence or absence of blowholes and of oxide pits and films. From the results of many experiments, and from a comparison of the properties of the test-pieces, they decided that the best results could be obtained by pouring within a certain range of temperature, viz., between 1,120 deg. and 1,270 deg. C. The actual temperatures were taken immediately before pouring by means of a platinum-platinum-irridium thermocouple.

Besides the blowholes and oxide pits they consider the most serious defect to be oxide films, which frequently follow the eutectic, in itself a brittle constituent, and a course of weakness if not properly distributed. These films are probably tin oxide, and are often associated with pits filled with the same substance. Heyn and Bauer,‡ in a paper on oxygen in copper-tin alloys, state that tin oxide (SnO_2) is insoluble in molten copper, and is either present in the solid as crystals or forms these films. Rawdon, dealing with the microstructure of Admiralty bronze, bears out this statement.

H. S. Primrose,§ in "Metallography as an Aid to the Brass Founder," mentions two pouring temperatures only, 1,100 deg. and 950 deg. C., the latter probably an error in printing, as Admiralty bronze solidifies at about 985 deg. C. In his opinion blowholes may be due to steam from the mould, occluded gases from the metal, or included oxides. The latter can only be removed by remelting with phosphor-tin or phosphor-copper. In metal poured at too low a temperature "intercrystalline pores" are formed by the quick uniform contraction of the casting.

None of these investigations, however, deals with the characteristics of the various types of unsound alloys that are liable to be produced when wrong pouring temperatures are adopted. This is somewhat remarkable, inasmuch as the different appearances of crystallisation are very striking. Neither do any of them give any information as to the gases in the fluid alloy whose separation and partial evolution during freezing are responsible for the unsoundness. So far as the authors have been able to ascertain the literature contains no analyses of these gases, and in the absence of this knowledge attempts either to get rid of them, or, better still, to prevent their presence in the alloy, must be purely empirical. A prevalent idea is that oxygen gas plays a considerable part in causing the unsoundness.

Understanding that, in spite of the existence of the publications alluded to, difficulties still exist in the foundries in this country in casting sound Admiralty bronze (88 : 10 : 2) the authors decided to undertake an investigation whose object should be, in the first place, to obtain fuller information on the exact cause or causes of unsoundness, and in the second place—assuming success in the first stage—to devise a suitable remedy. In coming to this decision they derived much benefit from conversations with Mr. J. Dewrance, himself the originator of this particular alloy, whose experience of its properties is very considerable. Further, he has kindly given them every facility in his foundry for carrying out their experiments, and his help has been of the utmost value and assistance.

No. 3

No. 2

No. 1

FIG. 1.—Admiralty Bronze Castings, machined to show structure, &c. No. 1 poured at 1395 C., No. 2 at 1235 C. and No. 3 at 1135 C.

Reduced 46% (of original castings) in reproduction.

From experiments carried out in the foundry alluded to, it was found that there are two distinct varieties of unsoundness: (1) When the metal was poured too hot, in which case the metal actually rises in the mould, and which is due to the formation of blowholes; (2) when poured too cold and the surface sinks. Between the two extremes there is a temperature range in which sound castings are obtained, the surfaces of which are flat. When poured too hot the metal is always unsound. The lower limit of unsoundness is not so well fixed, the castings generally showing holes, but not always.

About 50 lb. copper were melted in a gas or coke furnace. When molten the zinc was added and the temperature raised. The tin was added last after the pot was removed from the furnace. The total time the pot was in the furnace was on an average 45 minutes. The first cast was made as soon as possible, while the metal was at its hottest. It was poured into sand in rectangular blocks 3½ in. by 3½in. by 6 in. in size. Both wet and dry sand moulds were used with the same results. The temperature was taken in the crucible by means of platinum-platinum-rhodium thermocouple protected by a closed silica tube. After the first ingot has been poured the metal was allowed to cool until the right temperature was reached and then the second poured. After a further interval the third was cast. The following are the actual temperature readings for two series of castings. The first was made with best selected Mersey copper (furnace refined), and the second from electrolytically refined copper. The latter metal was just as it had come from the cathodes.

	1. Deg. C.	2. Deg. C.	3. Deg. C.
Mersey copper ...	1,445	1,225	1,137
Cathode copper ...	1,395	1,235	1,135

In each of those poured at the highest temperature the metal rose in the mould.

In order to determine the temperature at which the metal began to rise or "come back," a thermocouple was put into the metal immediately after pouring. This took place at a temperature just over 1,000 deg. C., when the outside of the casting began to solidify.

For examination, the ingots were cut in half and machined in a special way devised by Mr. Dewrance, which shows the crystalline structure and any flaws present. A cut of $\frac{1}{16}$ in. depth is taken with a feed of $\frac{1}{16}$ in. with a very sharp square-pointed tool $\frac{1}{16}$ in. wide. This method obviates the use of etching reagents which in this case would tend to increase the size of the holes (Fig. 1, annexed; Fig. 2, page 352).

The most unsound ingot was that poured at the highest temperature, and was made from Mersey copper. Of those made from cathode copper, that poured at the highest temperture was also very unsound but had not risen in the mould to the same extent as the former. Both those cast at 1,235 deg. C. and 1,225 deg. C. respectively were perfectly sound, and those poured at 1,135 deg. C. were very good. This emphasises the fact that it is very easy to get unsoundness by pouring at a high temperature, but it is not so easy to err on the other side and get unsoundness due to pouring at too low a temperature. The blowholes were bright almost without exception, indicating that the atmosphere was reducing, not oxidising. Practically every variety of copper was tried with the same results. Also it appeared immaterial whether the melting was carried out in a coke or gas furnace.

Chill castings poured at three different temperatures showed considerable differences in crystal size, but they were all apparently quite free from blowholes. That poured at the lowest temperature was unsound in the centre, due to piping. On examination under the microscope, however, that poured very hot was seen to be full of minute holes. Figs. 3 and 4 show the relative size of blowholes in sand and chill castings respectively.

Provided the metal is allowed to cool in the crucible, however much it may have been overheated, it is obtained quite free from blowholes. This applies to an alloy made for the first time or to previously cast metal which is remelted. This is to be expected, or sound castings would be unobtainable. By alternately pouring from about 1,400 deg. C. and allowing to cool in the crucible, the same metal is rendered alternately unsound and sound. The actual casting operation, therefore, provided the temperature is sufficiently high, is the deciding factor in producing porous metal. Experiment showed that there is a drop of about 100 deg. C. in the temperature of the metal in passing from the crucible to the mould, and this, occurring as it does so suddenly, is quite sufficient to alter the state of the metal.

From the above observations it will be evident that the nature of the copper and the various impurities in it have little or only a minor influence. The temperature, however, is all-important, and provided this can be regulated and controlled there should be no difficulty about always obtaining good castings.

The microscopic examination yielded no further evidence with regard to the formation of blowholes. It did, however, reveal the presence of a large number of oxide inclusions. These were often associated with the δ copper-tin constituent, and looked as if they had been pushed there in the process of solidification. In addition to these there were fine networks of oxide films light blue in colour. In Fig. 5 these films appear dark. Some of the oxide had the characteristic blue colour of cuprous oxide, but by far the greater part was much darker in colour. This was sometimes associated with the cuprous oxide, as shown, for example, in Fig. 6, or it existed by itself in various forms. Fig. 7 shows a large inclusion, the lighter constituent being the δ copper-tin constituent. In some other cases yet another distinct type was found, which was either square or rhombohedral-shaped according to the section (Fig. 8). This photograph was taken of a section of an alloy which had been remelted and recast several times, and finally contained no zinc whatever. It is very probable that these three constituents are the oxides of copper, zinc, and tin respectively.

Zinc and tin act as deoxidising agents to copper in that they reduce the cuprous oxide, themselves being oxidised in the process. Zinc oxide comes to the top and burns off or is skimmed off together with the tin oxide. If they are not completely removed they are carried down by the stream of molten metal into the mould, and are really mechanical impurities. Cuprous oxide, on the other hand, is soluble in molten copper, and only separates after the alloy begins to solidify. Provided the amount of cuprous oxide in the original copper is not excessive, 2 per cent. zinc is sufficient to reduce it, so that by the time the tin is added there should be little or no cuprous oxide left to reduce.

It is very difficult to distinguish between tin and zinc oxides. A copper-tin and a copper-zinc alloy were made by melting the copper and adding the tin or zinc and cooling immediately. In each was found a dark bluish-grey oxide, so much alike that it was almost impossible to distinguish between them. The only difference was in their behaviour to ferric chloride and hydrochloric

* Paper read before the Institute of Metals on Thursday March 14, 1918.

† Technologic Papers of the Bureau of Standards, No. 59: "Standard Test Specimens of Zinc Bronze."

‡ *Zeitschrift für anorganische Chemie*, 45.

§ Journal of the Institute of Metals, 1910, vol. iv. p. 248.

CASTINGS OF ADMIRALTY BRONZE.

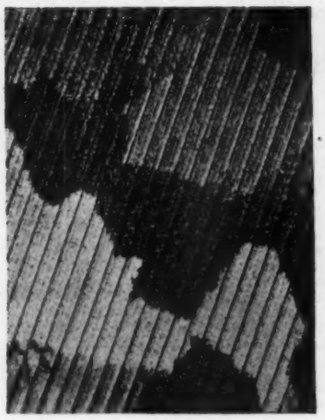


FIG. 2.—Showing method of machining. Magnification 8 diameters.

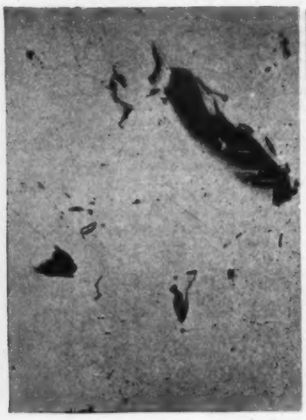


FIG. 3.—Sand casting, unetched. Magnification 150 diameters.

FIG. 4.—Chill casting, unetched. Magnification 150 diameters.

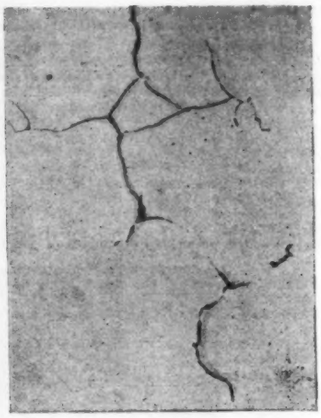


FIG. 5.—Oxide films, unetched. Magnification 500 diameters.

FIG. 6.—Oxide inclusion, consisting of two oxides, unetched Magnification 500 dia.

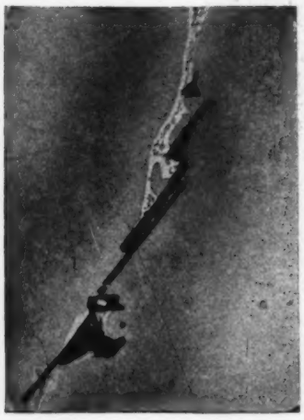


FIG. 7.—Oxide inclusion, unetched. Magnification 500 dia.

FIG. 8.—Oxide inclusion, unetched. Magnification 500 dia.

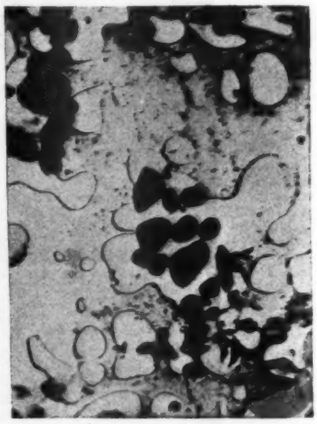


FIG. 9.—Cu_2O light. ZnO dark. Magnification 500 dia.

acid. The zinc oxide dissolved, whereas the tin oxide was unattacked. If the heating is continued after the addition of the tin or zinc, the oxide comes to the surface. Fig. 9 is a photo-micrograph of a section from the top of a copper-zinc alloy cooled in the crucible showing the cuprous oxide (light) and the zinc oxide (dark) in the oxidised surface layer of the alloy.

It is a generally accepted fact that blowholes are caused directly by the evolution of dissolved or trapped gas during the solidification range, and in the case of copper or its alloys this gas is generally considered to be oxygen. Steam from the sand may account for those holes on the outside of the mould, but cannot be responsible for all. It was decided that the most suitable way of determining the cause and possible prevention of porous castings was to investigate the gas or gases which are actually dissolved and trapped in the metal.

The solubility of gases has been most fully dealt with by Sieverts. With regard to the general physical relationships between gases and metals, he states* that, the temperature being constant, the solubility of the gases, both in liquid and solid metals, is proportional to the square root of the pressure. With rise of temperature the solubility increases, and there is a large increase at the melting point. For example, one volume of copper gives off two volumes of hydrogen on solidifying. In another paper Sieverts† determined the solubility of various gases in copper at a given temperature. He found that nitrogen is insolubie and used it as a standard, so that by melting the copper under nitrogen and the gas whose solubility it was desired to determine, he was able to calculate approximately the volume of gas absorbed by a comparison of the pressures in the two cases. According to his experiments, both carbon dioxide and carbon monoxide are insoluble in copper.

Sulphur dioxide‡ is soluble in molten copper in increasing amounts as the temperature rises, and on solidification 80 per cent. of the total amount absorbed is retained. Its solubility is lowered by the presence of sulphur and oxygen owing to the reversible reaction:

$$S\,O_2 + 6\,Cu \lesssim Cu_2S + 2\,Cu_2O.$$

Heyn,* in a paper on oxygen and copper, proved that the oxygen exists combined with the copper as cuprous oxide. In the liquid this forms a homogeneous solution with copper, but is insolublè in the solid. The eutectic freezes at 1065 deg. C., and has a composition of from 3.4 to 3.5 per cent. Cu_2O.

Heyn and Bauer in the paper already referred to have shown that in copper alloys containing tin the oxygen is in the form of crystals of tin oxide, which are insoluble in the molten as well as in the solid metal. The tin reacts with the cuprous oxide present with the formation of tin oxide, so that it is impossible for cuprous oxide to exist in the presence of metallic tin.

Guichard† attempted to solve the problem by a somewhat different method. He heated pure electrolytic copper in the form of blocks and wire *in vacuo*, and analysed the gases evolved. He only heated the metal to 600 deg. C., and found that the volume of gas obtained depended very much on the surface exposed; 100 gramms. of copper wire gave off 6.56 c.c., of which 62 per cent. was carbon dioxide and 38 per cent. hydrogen and nitrogen, between which he did not distinguish.

Guellemin and Delachanal‡ estimated the volume and composition of the gas obtained by heating certain alloys of copper and tin *in vacuo*. The pieces were taken from sound and unsound forgings, and the gas consisted of hydrogen, carbon dioxide, and carbon monoxide. The sound forgings gave off 90 per cent. hydrogen, while the unsound gave larger proportion of carbon monoxide and carbon dioxide.

The work of the last two authors is the nearest approach to that attempted in the present research.

(To be continued.)

* *Zeitschrift für physikalische Chemie*, 1911, vol. lxxviii.
† Berichte der deutschen chemischen Gesellschaft, 1910.
‡ *Zeitschrift für physikalische Chemie*, 1913, vol. lxxxii.

* *Metallographist*, 1903, vol. iv.
† *Comptes rendus*, 1911.
‡ *Ibid.*, 1908, and 1910.

THE MERCHANT SHIP OF THE FUTURE.

*Problems of the Future in the Design and Construction of Merchant Ships.**

By Mr. W. S. ABELL, M.Eng., Member of Council.

1. RESEARCH in naval architecture as well as in all branches of engineering received much attention in pre-war days, and the necessity of encouraging investigations in all directions was beginning to be realised by the commercial world when war broke out.

The shipbuilding industry of the United Kingdom passed through at the outbreak of war, a difficult period of acute competition. The demands for new ships until 1911 were below the capacity of the constructive establishments, and the period of 1913–14 witnessed the greatest output this country has ever attained. It is probable that if the war had not intervened the demand for merchant ships would have again fallen off, and that the shipbuilding world would have experienced another phase of rather acute depression.

It is considered that such competition had resulted in a close study of shipbuilding methods and processes, and that as far as the production of ships *qua* ships was concerned, the United Kingdom as a whole was capable of producing them in a most economical manner. Every effort appears to have been made to reduce the weight of material, and in some directions advances had been made in obtaining increased output of labour.

The rules of the Registration Societies imposed a limit upon reduction of weight, and beyond this the only saving possible involved considerations of redistribution of structural material. In general such redistribution required increased labour for fashionment and erection, so that once more a balance was reached between what may be termed the demands on labour and the limitations of material.

Although it is not suggested that further saving is impossible in respect of labour and material for ship construction of the future, yet it is particularly true

* Paper read at the Spring meetings of the fifty-ninth session of the Institution of Naval Architects, March 21, 1918.

that in pre-war days the only feature of importance which was closely and scientifically investigated was the question of the resistance and propulsion of ships as affected by the form of the vessel and by the performance of propellers.

Without detailing the various factors which dominate the post-war position, it is evident to all connected with the shipping and shipbuilding industries that the British Empire will have to make strenuous efforts to regain its pre-war maritime supremacy, in view of the disturbance of that position brought about by the present war. And not only is this the case, but the shortage of world tonnage will also require material and labour for shipbuilding to be employed to the greatest advantage.

2. Consequently it is imperatively necessary to enlarge the field of vision and research in order to include every phase of shipping, whether shipowning or ship production. For this purpose, it appears that in this matter of research much closer co-operation is required in the future between all branches of the industry, between the underwriter, the shipowner, the shipbuilder, and the marine engineer. It is to the interest of all these parties that the work of marine transportation shall be carried on with safety and efficiency; consequently it is to the interest of all those concerned in the maintenance of the sea power of the British Empire to stimulate and to provide financial assistance for broad schemes of research on shipping questions.

3. In order to realise the value of any particular phase of research, it is necessary to have a touchstone which will indicate the effect of an investigation on the general shipping position. For that purpose it seems necessary to lay down some definition of the function of a ship.

The most successful vessel is that which obtains the greatest power of transportation at minimum cost. Power of transportation may be defined as the quantity carried per unit of time. It is not sufficient for a vessel to carry a certain deadweight alone, but it is necessary that such weight be transported at a given speed, and that the relation of capacity to deadweight be such as to utilise the maximum draught which the dimensions and strength of the vessel permit.

The cost of operation depends on: (*a*) First cost; (*b*) maintenance; (*c*) seaworthiness and safety; (*d*) number and nature of crew; (*e*) fuel; (*f*) speed; (*g*) time spent in port. These factors are to some extent closely related, and the realisation of a proper balance between them depends largely on the problem set by the shipowner to the shipbuilder. It may, for example, be good policy to accept a low first cost and subsequently to dispose of a vessel at a period when the cost of maintenance exceeds a certain percentage. The demands of the shipowner may embrace deadweight and cubic capacity, speed, and tonnage. It is then the part of the shipbuilder in open competition to produce the lowest first cost and disregard any factors other than those directly specified. The builder cannot, however, ignore the fact that if quotations are equal, preference will be given to the vessel which makes least demands on labour and material for operation. The shipowner has the greatest experience of these factors, and consequently it is in directions such as these that he should give encouragement to research.

4. This discussion of the economics of ship operation brings out certain features which, in view of the needs of the future, require close study. The questions of labour and material required for operation involving economical production of power are mainly for the consideration of the marine engineer. The relation of power to speed has received, and no doubt will continue to receive, the attention it deserves. It may now be of interest to proceed with a more detailed account of the directions in which future research should be encouraged, deferring until later questions relating to economy of production.

A. Economy of Ship Operation.

5. *Resistance of Ships.*—A large amount of data has been accumulated as the result of the form experiments made in the various experimental tanks of this country, as well as elsewhere, notably in the United States. As a consequence, it is possible now to obtain a fairly close approximation to the plain form required for a given displacement, length and speed. Such results are of great value when used on comparable forms, but much work still remains to be done to complete the knowledge of the various corrections to be applied to the results of model experiments in order to obtain the data for the full-size vessels. There is no doubt that the resistance of the model as regards wave-making can be very accurately measured, and there is also very little doubt, if any, that the wave-making resistance of the full-size ship is accurately given by a scale correction of the model results.

It is to be observed, however, that in the large majority of merchant vessels the wave-making resistance is only some 20 per cent. of the total resistance, the remainder being due to skin friction and eddy-making. The frictional resistance requires to be estimated, and here the basis of calculation is determined by experiments which have been made mainly on planks of small area and of lengths not exceeding 50 ft. The extension of such results to the ordinary merchant ship of, say, 400 ft. in length, and particularly to the large fast liner of, say, 800 ft. in length, is largely a matter of conjecture. Moreover, the nature of the surface has a large effect on the calculation. The general trend of such results as exist indicate that with a paint or varnish surface the frictional resistance per unit area at given speed diminishes with the length. If the estimates of power are to be more closely approximated to in future, it is essential that some large-scale experiments on frictional resistance of full-size vessels should be carried out in order to obtain some basis to correct the frictional calculations obtained from model experiments.

6. *Power Required at Sea.*—The usual tank experiments provide an estimate for power in terms of speed, under what is termed "still-water conditions." It is becoming increasingly necessary for cargo vessels employed on liner routes to be very reliable in time-keeping between port and port, and to be largely independent of the variation of weather conditions. This can only be obtained by providing a reserve of power beyond that necessary for still-water propulsion, and the estimate of such margin is largely a matter of experience. It is not an easy task to obtain even an approximation to the loss of speed brought about in rough weather, and it is still largely a matter of opinion whether the form which is most suitable for speed in smooth water is the best form for speed-keeping under average conditions. In order to obtain data, it would be necessary to run model experiments, to have a fully loaded measured mile trial of the vessel, and to analyse to some extent (making allowance for weather conditions) the performances of vessels on service. There do not appear to be great difficulties in the way of such procedure, provided shipowners will co-operate on a generous scale.

7. *Resistance of Appendages.*—Model experiments are determined for a "naked" ship; that is, certain appendages are omitted, such as shaft brackets, shaft bossings, rudder posts and rudders, and bilge keels. It has been found that on the small scale of the model, the addition of such appendages tends to increase resistance out of proportion to the effect produced in the full-size vessel. There is no doubt, however, that the resistance of these appendages is of importance, not only as regards form, but also as regards performance of propellers. It follows, therefore, that experiments on a large scale would be of assistance, and might conceivably form part of the proposed friction experiments on a full-size vessel.

8. *Screw Propellers.*—Although much attention has been given in many directions to model experiments with screw propellers, yet, in view of the enormous complexity surrounding the problem, it is still possible for an expert to design a bad propeller. The sensitiveness of the screw to any slight variations in proportions is well known, and consequently, in view of the difficulties of determining the velocity of the water in the vicinity of the propeller, which in general is merely guessed at, it is apparent that an extension of knowledge would be of benefit to all concerned. Here, again, the advantage of some methodical series of large-scale experiments co-ordinated with complementary experiments in a tank will be of service, and will further help to establish a proper relation between the performance of a model and the actual vessel. There are many well-known troubles with the propeller which need not be particularised here, but some attention may perhaps be drawn to the desirability of arranging the form and shape of blades so as to reduce vibration to a minimum. It will also be helpful if shipowners would, as occasion offers, carry out measured mile trials of fully loaded vessels, and have the results carefully analysed. Care would have to be taken to obtain accurate measurements of pitch, diameter and area, and form of blades. Moreover, when the trial data were available, the information could be supplemented by careful logs of sea performance under different weather conditions.

9. It is now opportune to discuss certain points for research, which although having features in common, yet perhaps may be differentiated into two main classes, viz., factors of design and questions underlying economy of production of vessels.

Factors of design might include questions relating to: (*a*) Seaworthiness; (*b*) safety, involving (1) stability, (2) subdivision; (*c*) time spent in port; (*d*) relation of deadweight to capacity.

10. *Seaworthiness.*—Questions of seaworthiness and sea-kindliness have been discussed on many occasions with advantage. The factors which tend to facilitate good time-keeping are largely height of platform forward, coupled with sufficient reserve of buoyancy. The proper relation of breadth of vessel to depth to the upper or bridge deck is also of more importance than is commonly accepted. It is true that a moderate breadth favours easy rolling, but, on the other hand, it may prevent reasonable economy in working the vessel in average trades by requiring an undue amount of ballast. It has been said that there are more fashions in ships than in feminine attire; be that as it may, there is a certain cycle in operation which recurs at intervals of some twenty-five to thirty years. There was a tendency just previous to the war to revert to narrow and deep ships, such as were shown to be dangerous some thirty years ago. The tendency was not, perhaps, very marked, yet, owing to the adoption of the shelter-deck type and the subsequent addition thereto—found necessary by sea experience—of forecastle, bridge and poop, the narrow and deep type was being slowly approached. Recent investigations made by the Loadline Committee have shown that the ordinary three-island vessel with long bridge and two short wells with good proportions and with the ordinary freeboard is probably the most seaworthy type of those at present in vogue.

11. *Stability.*—Stability at sea, although perhaps the want of it is fortunately not often experienced, is of great importance. Present knowledge of the subject is confined to statical calculations; estimates of the arm of righting couple and the angle of vanishing stability for the ordinary merchant ship are seldom made. The question of initial stability and the determination of the metacentric height are generally not considered, or at best only evaluated in an empirical manner, and very few attempts have been made to deal with the general question of the stability of a vessel in a seaway in terms of dimensions.

A ship among waves and exposed to wind pressure is subject to displacement from the position of equilibrium by reason of the energy transmitted from the wave and wind systems. This energy is absorbed in two directions: (1) by the resistance of the form and keels to rolling, and (2) by the righting couple due to the inclination of the vessel. It is possible to calculate approximately, or to deduce from model experiments, the rolling resistance in still water, and it should also not be difficult to approximate experimentally to the same factor when a model is exposed to a regular system of waves. The righting couple is calculable both for still water and approximately so for a regular system of waves. Consequently it seems possible to deduce from experience the curve of stability which should be provided for a vessel of given dimensions when exposed to heavy weather. Expressed generally, the quantity to be determined is the work required to capsize the vessel, and this quantity is the difference between the energy transmitted by the wave and wind systems and the resistance to rolling among waves.

Detailed reports of the experience of vessels in bad weather would give the basis of such determinations, care being taken to obtain the relative speed, magnitude and direction of the wave and wind systems, and the speed, displacement, position of centre of gravity and rolling of the vessel, which factors are not difficult to obtain with sufficient accuracy.

12. *Watertight Subdivision.*—This question received much consideration in pre-war days, and rules for the subdivision of passenger vessels were drawn up in this country, although, owing to war conditions, the introduction of these regulations has been deferred for a time. Experience of submarine warfare appears to show that some further consideration is required, more particularly in regard to the relation between nature and extent of damage and amount of subdivision. For example, if the expected damage be mainly vertical in extent, then it appears reasonable to adopt a standard of subdivision which involves a fractional number of compartments open to sea. But when damage extends for a considerable distance longitudinally the chances of loss of a bulkhead are largely increased, and in this case it appears necessary to conform to an integral number of floodable compartments. In other words, while it may be reasonable in the one case to aim at a standard of subdivision equivalent to, say, 1½ compartments flooded, in the second case the choice would lie between either a one-compartment or a two-compartment standard. The difficulties of the present modes of calculation have been already pointed out in several directions, and it certainly appears desirable, in view of experience, to attempt to find a modified system of rules which would be as easy of application as possible, having regard to the necessities of the case.

13. *Time Spent in Port.*—It is not generally recognised that the great majority of vessels spend perhaps half their existence in port. During this period the vessel is unproductive—i.e., is piling up charges and is not earning freights. Even in long voyages from this country to the most distant parts it is not uncommon to find that only 60 per cent. of the time is passed at sea. For economical transportation it appears vitally necessary to study every method which will reduce this drawback, not only with reference to ports, harbours and railway facilities, but also with reference to the vessel herself. It appears that this factor is one of supreme importance in design and has not received the attention it has deserved. For example, there must be an economic relation between the length, breadth and depth of holds. A narrow, deep hold, except perhaps for bulk discharge, must obviously be more difficult to work than a broad and shallow space. Again, there will be a close economic relation between size of hatch and area of hold space and between the ratio of 'tween-deck space to hold volume. Great attention has been paid to the discharging appliances, but there is no doubt that even here a close study of the economic requirements will result in savings in many directions.

14. *The Relation of Deadweight to Cubic Capacity.*—It is admittedly a difficult matter to determine the proper relation between the deadweight carried and the space available for stowage in the case of the cargo tramp. But as owners work more or less through fixed agencies it will happen that after a time conditions somewhat approximate to stability, and within limits a ratio can and should be obtained. It is extremely desirable that a vessel should carry as much weight as possible, but the determining factor in the tonnage of this country in the past has been the imports of raw material, which are relatively bulky. Consequently on the supposition that pre-war conditions are maintained—and they must be, since the sea power of this country is largely determined by a thriving industry in the United Kingdom—the aim must be capacity rather than deadweight. The proper relation for general purposes of these two quantities is therefore an important question for broad research. With given dimensions, capacity can only be gained by reducing deadweight and by reducing the machinery space.

B. Economy of Ship Production.

15. The aim of the shipbuilder is to produce at the lowest possible first cost, subject to a proper provision for wear and tear, an instrument of transportation which will carry a given quantity of goods at a desired speed. It is, therefore, of importance to study two broad factors—economy of material and economy of labour. Both these factors must be considered in conjunction, since in general, saving in weight involves increase of labour, and it is of little use to build a vessel so light that the increased first cost becomes prohibitive commercially. With this restriction in mind, it is best to consider the material side of production independently of the problems relating to labour.

C. ECONOMY IN MATERIAL.

16. Before it is safe to introduce variations in disposition of the material in the structure, it is necessary to have a clear understanding as to the functions of the various members. In short, it would be of advantage to reason out an anatomical-analysis of the duties performed by longitudinal, by transverse, and by the various local details which experience shows to be necessary. It is comparatively easy to increase the proportion of the material employed in the longitudinal direction, but this must not be done at the expense of transverse or local strength. Consequently, since each of these three important points have to be correlated, any close study of the structure of a vessel will be of enormous advantage in facilitating future progress.

17. *Distribution of Material.*—It has been rather unfortunate that in past times it has been conventionally agreed that certain parts of the structure are only called upon to meet strains in one direction—that is, the straining forces have been analysed in respect of either the longitudinal, transverse, or local senses. In general, however, some parts may be called upon to bear stresses arising from both longitudinal and transverse straining actions as well as local conditions. It is largely a matter of conjecture what provision is necessary to bear the combined results; it is not in general true to infer that the material must be sufficient on the one hand to withstand either the maximum strain in any sense, or, on the other hand, to assume that the arithmetical sum of the strains must be met. In considering redistribution of material, therefore, it will be desirable, as far as practicable, to depart from this present convention and to estimate the interaction of adjoining parts of the structure under combined stress. Any attempt to reduce weight must generally have as its basis an increase in longitudinal material. For since the maximum strains on a vessel occur in the longitudinal direction, the more material is massed in that direction, the more is the stress on the material brought into line with that experienced in other directions. In the same manner, saving of weight is effected by reducing the transverse allocation of material to the minimum necessary for that purpose. The manner in which transverse straining action is met is still very obscure; and although some methods of calculation are available, yet these methods are from the very nature of things complex, and so difficult of application that their common use is still far distant.

A research into the possibilities of maximum amount of material for longitudinal distribution and a minimum amount for transverse requirements is eminently desirable. But coupled herewith must be considered the alterations in works processes which are likely to be required. Local strains are still more difficult to evaluate, and can only generally be met by a close study of experience at sea. Merchant vessels are particularly prone to sea damage at the forward end, both in the side plating and in the double bottom. The heavy and unusual duty performed by vessels in war time has accentuated the difficulties ordinarily experienced. Again, although the fibre stress per unit area which material will stand is ordinarily known, or in a ship rather comparatively determinable, yet, under compression, failure may and commonly does occur owing to insufficient local support. There is therefore to be sought a relation for spacing supporting members in terms of the thickness of material, such as a deck which has to be supported against compression. This discussion on local failure brings up the question of secondary bracing. Certain girders and stringers require brackets in order to prevent collapse from oblique loading; it is not an easy matter for any form of calculation, but a close study of actual experience should produce rules for general guidance.

18. *Construction of Double Bottom.*—Even the most enlightened naval architects appear to have only hazy ideas concerning the structural work performed by the complicated double bottom which is now a common feature in merchant ships. The more general practice is to dispose the internal framing in the transverse direction, retaining a very small amount of longitudinal material mainly for local support. These longitudinal intercostal members also fulfil some function as secondary bracing, but the nature of the work performed is very obscure. It is, of course, true that facility of erection has favoured transverse framing; but here, again, if economy of weight is required, search must be made for a distribution which is more in the longitudinal sense than the present practice. Some well-known efforts have already been made towards this aim, but the final solution has yet to be sought. It certainly seems possible to make some comparative calculations on the strength of the double bottom as a whole when regarded as a strut under compression. The labour involved is, however, immense, and so far no one has attempted a solution. The double bottom of a merchant vessel suffers much from inaccessibility, and any development which would mitigate this important disadvantage would be welcome so long as the structure were able to perform its work efficiently.

19. *Stiffness of Structure.*—Although stiffness and deflection are closely studied in land structures, yet as far as ships are concerned insufficient attention has been paid to this important matter. It is certainly true that the Registration Societies provide some safeguard against undue deflection, which limitation is expressed very generally as a proportion between length and depth of structure. It is extremely desirable for economy of material to extend our knowledge of this branch of study in order to obtain the best disposition of material. Something can certainly be done by experiments on the breakage or deflection of vessels when loaded, in comparison with the results of calculation. Such experiments were made in the early days of shipbuilding, but further work on more modern forms of structure is most desirable. Attention might also be called to the necessity of giving more consideration to the question of stiffness of transverse and longitudinal framing. It is difficult even to give an idea as to the form such an investigation would take, as the calculations required are much more involved than those for transverse strength already mentioned.

20. *Efficiency of Connections.*—This question is of the highest importance, since it is of little use to provide structural material and then court failure in the method of attachment. The experience of many years certainly indicates that, generally speaking, the present systems of riveted connections perform their work well in regard to main structural stresses, and in cases of local stresses the alterations dictated by experience have fairly well met the needs. The growth in size of vessels has resulted in increased size of rivets with a consequent need for the greater use of power tools. It has, however, become desirable to ascertain whether, under modern conditions, it would not be possible to make alterations in methods of connection and reduction in sizes of rivets without sacrifice of efficiency. There is not sufficient information at present available to indicate precise directions in which investigation might possibly proceed. It is to be hoped, however, that this defect of knowledge will be remedied in the not too distant future.

D. ECONOMY OF LABOUR.

21. Although post-graduate research scholarships in naval architecture have been in operation for some time, and although the attached conditions clearly contemplate that research students should investigate the development of the shipbuilding industry at home and abroad, yet so far this important purpose has not been realised. The increase in the remuneration of labour, and the paramount necessity of the country in post-war times to maintain its previous industrial activities, makes it necessary closely to investigate economy of labour in shipbuilding operations. Study of labour processes has already been somewhat widely undertaken in some branches of the engineering industry, but this study has been largely confined to the mechanical side, and it would appear that insufficient attention has been given hitherto to the question of shipbuilding.

The question appears to be dominated by two main considerations:—

(*a*) Increased output of labour, and

(*b*) Disposition of material to ensure a minimum amount of labour.

Increased output of labour involves the provision and proper utilisation of labour-saving devices, but here it must be remembered that saving is not effected unless the time factor for an operation is properly related to the time factors of the other processes. For example, it would be useless to speed up the preparation of plates unless the output of the supporting framing were adjusted equally. Consequently, although one particular class of employee would be producing at a higher rate, the periods of delay in other processes would reduce and prevent any ultimate gain.

The need of the study of the problem as a whole, and not for particular items, is at once evident, for otherwise labour must raise objections to an introduction which would not ensure continuity of employment. On the other hand, the workman must recognise that he is unable to increase his earnings without a corresponding co-operative effort on the part of the employer to regulate the other branches of the establishment. Increased output is therefore only possible by the joint effort of employer and workman, and by a joint increase of remuneration for both parties concerned.

It has often been mentioned that low first costs involve savings of both material and labour. On the other hand, reduction of weight often involves a redistribution of material, and it may happen a consequent increase in labour. A close study of the labour charges for each structural detail is necessary in order to obtain a proper balance, and it will often happen that the disposition of material will be determined rather by labour requirements than by structural necessity, although at the same time the strength must be properly maintained. It is certainly true that individuals have given careful attention to this point in the severe stress of pre-war competition, but this very fact has prevented that interchange of ideas which would be of the greatet value to the industry as a whole. It may be of interest to give some detailed views of the directions in which the study of labour problems might possibly be undertaken.

22. *Work Preparatory to Construction.*—There appears to be room for improvement in drawing-office and mould-loft practices, which ought to bear a close relation to the labour processes required for actual construction. Study of form and disposition of plating would tend to reduce scrap and to avoid much shaping of plates. It would be a great advantage if plates could be made rectangular in shape for a good portion of the length and the material then be ready for use as delivered from the steel works. It is considered that even towards the ends it is possible to introduce more parallel plating than is commonly done. Further, the use of templates should be reduced to narrow limits either when provided from the mould loft or when obtained from the ship during erection.

23. *Fashioning of Material.*—The increased use of parallel plates already mentioned will avoid shearing if the steel works shape the plate as nearly as possible to the dimensions. The trimming of butts and edges might conveniently be studied with a view to save labour. Recent developments in the use of the multiple punch for ship work have shown that this system can be well adapted, and that to a large extent for shell and deck plating. It appears that a careful study of the plating model will enable this system to be conveniently applied well towards the ends of the vessel. The form might also be conveniently adjusted with the same point in view. Smiths' work, which is both costly and difficult, might be increasingly avoided by arranging for repetition work as much as possible, and fashioning these parts in numbers by hydraulic presses. The avoidance of templating at the ship must lead to increased output, and here again arrangements for repetition work would be of great advantage.

24. *Erection, including Connections.*—This question involves careful consideration of berth appliances, a subject for close study in itself, and one which has frequently been discussed before this Institution. The sizes and weights of the pieces to be handled are of importance, and such pieces should be as large as conveniently possible to reduce labour of connection. The structural details should be so arranged that the parts are conveniently attached, and can be temporarily placed in position without much adjustment and without distorting appreciably under their own weight.

The use of power riveting tools can, in the opinion of most builders, be largely extended, more particularly perhaps in the direction of pneumatic appliances. In this case, however, great care is required in the periodical inspection of the tools and of the plant in order to obtain a sufficient and constant supply of power at the ship, and in order to ensure that the riveting machines are giving out the proper power in relation to the consumption of air. It appears necessary to devise certain simple tests and gauges which shall indicate these requirements. Power riveting has become of increasing importance with the modern increase of size of merchant vessels and the consequent increased thicknesses of material. The extension of hydraulic riveting is therefore, of some importance, but hydraulic power is not so conveniently applied, and is expensive in operation.

There are also indications of a future possibility that some forms of electric welding may be adapted for structural work. In such case it will be necessary to devise works processes suitable to such forms of connection which must involve departures from existing methods of erection.

25. *Completion of Vessels.*—In the later stages of construction it is necessary to devote considerable attention to the fitting of the equipment, the navigation instruments, and the multitudinous items necessary to the proper working of the vessel. It would appear to be to the advantage of the whole industry to take steps to secure bulk manufacture of these numerous small details by setting up standard forms. It also appears desirable that steering gears and engines should conform to certain standard specifications, and that boats and davits should be of interchangeable patterns. The study of cargo-handling appliances, winches, blocks and so forth would result in saving of cost and increase of output. In fact, the question of equipment would repay careful investigation by the industry as a whole with a view to the adoption of bulk production.

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26. It has not been possible to give more than the merest indications of the directions which investigation should take in the wide field of naval architecture. It appears that there is much room for study—very much more room than was expected when this paper was begun. It will be admitted that the aim of this country should be to re-establish her maritime sea power at the earliest possible moment. It is therefore beyond doubt, in view of the stringent economic conditions that must prevail when peace is declared, that there is a striking and immediate necessity to study the factors which will improve the production of vessels, or, in other words, to encourage a widespread interest in research in naval architecture. It is to be hoped that in the national interest the whole of the shipping community will work together, and not expect research to be undertaken by any one section of the industry.

RESEARCH IN MARINE ENGINEERING.*

Some Notes on the Importance of Research in Marine Engineering.

By MR. A. E. SEATON, Member of Council.

THAT scientific research is necessary for marine engineering is a general proposition which will be accepted without a dissentient voice; but when put into concrete form with definite proposals as to its nature and scope there will not be, I fear, the same unanimity; what I dread most, however, is that wet blanket of apathy which is worse than active opposition and has done more than anything else to kill such research of a methodical nature as has been attempted in the past. My desire, therefore, is to place this question and all that pertains to it in such a light as to arouse the enthusiasm of the rising generation of marine engineers and of all others interested in that branch of engineering; to maintain their interest in true research, so that the energy and experience of those having the power to promote it may be enlisted, and to ensure that those who have the means may be induced to provide them and give an opportunity for those engaged in such important and profitable work to carry research to a satisfactory conclusion.

To that end it will be well to have a clear understanding as to what is meant by Research. The following definition of this word, which is taken from a dictionary, is helpful for a start: "Research is a laborious and patient search as for truth—a diligent inquiry or examination in seeking facts or principles," and for the verb research, "To examine anew." For the latter I am especially obliged to the compiler; it helps me

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in something I shall have to say later on as an old engineer who often has found the advantage of examining anew what had passed muster as the truth with many a generation of his predecessors.

Now marine engineers have before them at all times and places certain phenomena—some familiar, others uncommon; these all have their causes and they themselves are generally effects. To understand them correctly more evidence is necessary than is generally supposed by the casual observer. It also often happens that among these engineers are men quite competent to observe and note all the facts and tender quite good evidence respecting them, but who are not so well fitted to arrive at the correct inferences to be drawn; just as in a law court the jury can ascertain and determine what are the real facts arising from the evidence, but it is the function of the judge, who is a specialist, to analyse them, differentiate between them, and show their legal bearing in an impartial manner so as to ensure that the verdict shall be right. The counsel on each side are often quite capable of exercising these functions, but they cannot avoid the bias which comes from interest nor fail to be influenced by a partiality for the cause they are advocating.

Unfortunately for the shipowner directly, and the public indirectly, there have been in the past two verdicts advocated by the counsel in engineering conflicts; and, what is worse, both have been acted on when it was evident that one of them must be wrong. The mistakes of this kind in the past have generally been perpetrated from want of adequate means whereby that diligent inquiry or examination in seeking the facts and principles could be carried to such a conclusion as to avoid misunderstandings on the one hand, and on the other to acquire the knowledge by which alone it is possible to follow up any course of useful investigation. But even if the means were available the men suitable for the work were not to be had; for those possessed of scientific knowledge and having had the necessary experience were generally too much engaged in following the avocation by which they lived to gain the time necessary for laborious and patient research, without which the truth is sought in vain. Consequently we find many instances where important inventions have been conceived in the past, and even in some cases tentatively experimented with, but not brought to the perfection necessary for practical use until years afterwards, when the inventor and his supporters were beyond reaping any benefit from them, and all for want of diligent inquiry or examination in seeking the essential facts and principles involved in them. It will, therefore, be instructive to take a few well-known cases of this kind, and also some others where research made in good time has led to a successful issue with an immediate reward for those who adopted it.

The screw propeller was proposed by Bramah as far back as 1785; it was tried by Littleton in a boat in 1794; fitted by Shorter to H.M.S. Dragon and Superb in 1802; but it was only dealt with seriously as a practical method of propulsion in 1836 in the steamship Archimedes. In H.M.S. Rattler in 1843 it was subjected to some further research by the naval authorities, which was carried out in such admirable, if costly, ways as to, at last, convince the public of what they might possibly have known fifty years before. Now these Rattler experiments, and many others made subsequently by the naval authorities with screw propellers, are still sufficiently interesting and instructive to repay the student for examining them anew. It is certain that had they been examined anew in 1877 there would not have been perpetrated such a fiasco as happened with H.M.S. Iris in 1878. No one, even with patient research, can now estimate the loss sustained by this country alone due to the dilatoriness in the "search for the truth" respecting the screw propeller which might have been employed for oceanic steamships with great advantage many years earlier than was actually the case. Nor can we have a true conception of the waste of fuel which went on year after year, after the screw propeller was adopted, from want of sufficient knowledge to design propellers so as to obtain the highest efficiency. Nor, on the other hand, can we estimate the great gain already actually attained by the patient, continuous and scientific research made in this country and America, by means of experimental tanks, by the Froudes and other members of this Institution whose contributions are lasting monuments to their skill, diligence and pertinacity in research.

Again, the compound engine, conceived by Hornblower in 1771, and improved by Wolff in 1804, was not fitted on shipboard till 1854 by Randolph and Elder in the Brandon, and in 1863 in H.M.S. Constance. Another ten years elapsed before it was adopted for general purposes, and then somewhat grudgingly. This was really for want of something like true scientific research as against what passed muster for it, as may be seen in the Transactions of this Institution. There was later a similar controversy and much heart-burning over the triple-compound engine, although it was introduced by so competent and scientific an engineer as the late Dr. A. Kirk in the steamship Propontis in 1874. Ten years later it was still being treated with considerable reserve. The research conducted with patience and skill by Sir Alexander Kennedy, however, was sufficient in the end to break down prejudice and remove all opposition. Had such work as his been carried out thirty years before on similar lines with the Brandon, enough money could have been saved by economy effected in fuel consumption alone to have gone far to pay the interest on the old National Debt. Besides, think how much mental energy was wasted in vilifying systems such as the various compound engines, which real research could have rescued from the prejudice of opponents.

The surface condenser was part of Cartwright's patent of 1794, and also of Brunel's in 1822; it was, however, only in 1837 that Samuel Hall got one tried in a practical way in the paddle steamer Wilberforce, and also on the paddle steamer Sirius, the first steamer to cross from England to America. But a year or two after the surface condenser was laughed out of existence on grounds which, had proper research been made, would have been easily proved to have no real foundation for condemnation. For want of it, however, a quarter of a century after, both naval and mercantile ships were being still fitted with jet condensers, and years after that cross-Channel steamers had them, instead of the surface condenser now in universal use, and said to be able to effect a saving of fuel in those days of 15 per cent. Think what that would have amounted to if the surface condenser could have been in general use from 1837 onwards! Methodical research respecting the surface condenser has since then been carried out by Mr. D. Morison and Messrs. Weir, and has resulted in developments in its construction and use that have improved the power and efficiency of marine engines immensely.

But perhaps the most notable instance of delay in benefiting by an invention is that of the steam turbine. Branca, so long ago as 1630, published the idea that a jet of steam impinging on the vanes of a wheel would make it revolve. He thereby established the foundation of the impulse turbine, just as Hero of Alexandria had so very much earlier discovered a reaction steam turbine and employed it for useful purposes. It was not, however, till 250 years after Branca that, while Sir Charles Parsons was making his first experiments with the reaction turbine, De Laval, a distinguished Swedish engineer, followed Branca's idea and made an actual impulse turbine. But even then he apparently failed at first to appreciate Branca's art in placing the nozzle, which was in the form of a human mouth, far enough from the vanes to permit of sufficient expansion before impact. By further research De Laval discovered why his first nozzles were so inefficient, and consequently found how to make an efficient impulse turbine. Why no engineer or scientist perceived that expanding steam had no other virtue than that due to pressure must, I think, have been really from want of proper research, and perhaps also from the contentment that comes of a good sedative phrase or aphorism. Our forefathers were told by some wiseacre that "Nature abhorred a vacuum"; they believed it, and, what is more, acted on it by applying vacuum-making engines to pump water from mines, and succeeded.

And when another genius arose in Birmingham who discovered that a grindstone crank handle might be moved round by a reciprocating instrument, the mill engine came into use; and finally the marine engine appeared, like the mill engine, in the form of a modified pumping engine, notwithstanding that a direct-acting engine had been used in one of the earliest attempts at steam propulsion (the Charlotte Dundas, in 1802). It is true that many quite early (1787) attempts were made to rotate a shaft direct by a rotatory engine, but they were all of them designed to be worked by the pressure of steam, and none by the dynamic energy of it on expansion. In other words, they were all of them pressure and none of them velocity engines.

Having shown what want of research has failed to do, I will now venture on what may be called the positive evidence of the proposition. It was by research that James Watt, himself not originally an engineer, made the discoveries that led to the great improvements he effected on Newcomen's engine, and later by the same means he made further and greater improvements on his own designs. It was by research that Stephenson's locomotive was transformed from being so extravagant in consumption of coal, that even among collieries it could not work profitably, into the engine as we know it to-day, for in all essentials there is very little difference between those engines and the locomotive of Stephenson's latter days.

The water-tube boiler was the invention of Goldsworthy Gurney, himself a doctor, who made a very extensive and complete study of the instrument by which steam could be rapidly and safely generated and yet so light as to be carried on a road vehicle. His research is shown by his various patents, and the success of his road carriages marks how good most of them were. It was unfortunate for him and for us that this research was late in fructifying in the minds of others, for Parliament in 1835 (and we should remember it was an early Act of the Reformed Parliament) decided, against the evidence of experts, that 4 miles per hour was the safe limit of steam road cars, and that a man in advance with a red flag was a necessary accompaniment. But for this Act, motor cars, 'buses, and wagons would have been in general use before the railways were made.

The submarine, with which we are now so much concerned, is the result of long-continued research. It is a far cry from Bushnell's and Fulton's early efforts of the beginning of last century to the wonderful submarines of the present day, and many were the steps from the crude attempts of those early days to the successes of to-day and many brilliant minds were at work upon the problem in the principal maritime countries of the world. Nordenfeldt and Garrett in England, Goubet, Zédé and Laubeuf in France, Holland, the Irish schoolmaster, and Lake in America, Laurenti in Italy—to mention only a few of those who have contributed to solving the problem of submerged navigation—were all men whose success was largely due to an incurable thirst for that knowledge which is acquired by patient and diligent search.

The torpedo, an old idea in conception, was taken up seriously by a landsman, Whitehead, who by his research and perseverance made such a success of it that it was quickly added to the armament of our own and foreign natives.

The steam turbine—to Sir Charles Parson's perseverence and tenacity of purpose in carrying on methodical scientific research is due the practical and commercial success of the steam turbine. In friendly competition with him De Laval, Rateau and Curtis have conducted research with the impulse turbine, and it is only by such means that they have attained success. Later on Sir Charles Parsons developed the idea of reducing the rate of revolutions of screw propellers to obtain high efficiency in them without reducing the rate of the turbine, by connecting the driver to the driven with toothed wheel gearing. The higher rate of revolution of the turbine now possible with such an arrangement has much improved its efficiency, so that the little loss due to the modern gearing has been much more than made up by the gain in general efficiency of the system.

By continued research other engineers have made the further improvement of double gearing, whereby with a rate of revolution of screw as low as that obtaining in the large cargo steamer, the turbine itself may be run at as much as 4,000 r.p.m.

The balancing of reciprocating engines, initiated by Sir Alfred Yarrow, has by scientific research been made a fine art, with great advantage to all having to do with ships, and it was the means of evolving the four-crank self-balanced engine, so much preferred in passenger and naval ships until the turbine superseded it for express services.

It will, perhaps, be an additional inducement to give scientific research its due if I go further and furnish an instance of how wrong things have been followed up at a great expenditure of time and money, most of which could have been certainly saved if the research had been methodical and scientific. Of this waste of time and money, the so-called hydraulic propeller is a good example, for if a fraction of the money spent on this device had been devoted to a "diligent inquiry for the truth," the remainder could have been saved. The patent fees alone spent on proposals of this kind of propeller would have gone a long way to that end. But it was only after the Admiralty had fitted a small ironclad ship with Ruthven's internal propeller and demonstrated thereby how lacking it was in efficiency that the public could be convinced. Even then another and more costly form was tried some time after by the Dutch with equally disappointing results. A shipowner once complained to me of the extravagance of his superintendent engineer in spending 700*l.* in one year on experiments which had been mostly failures. My advice to him was to let him spend much more, for, seeing there were 70 steamers under his supervision, it was more important for him to discover what things were wrong to have on shipboard and avoid them, even than to ascertain those which were good. He could generally find out all about the latter without troubling himself to make special experiments.

My object, therefore, is to concentrate attention now on this research work as being not only necessary and interesting, but really remunerative in results and of great benefit both to the individual and to the public at large, and to show that it may be so even when the results are negative in character. Further, to ensure that, in future, research work shall not be left entirely to unaided and individual effort, or even to the collective effort which in the past has been only too often unmethodical and sporadic, because unguided. To avoid this there must be found the means, the men, and the machinery for the following objects:—

1. Individual efforts and enterprise shall be encouraged, and when found to be in the right direction, they may be assisted so as to be carried to a successful issue without loss of time.

2. All individual efforts shall be as far as possible co-ordinated and combined, so that by united action higher efficiency and quicker development in practical results may be attained in solving each problem dealt with at the least cost.

3. Definite and systematic study of each and every proposition that the marine engineer is faced with should be made in such a way as to be free from all personal prejudice or interest, and its development be proceeded with.

4. To study the possibilities of every project with a view to the public good, so that inventions, or even mere ideas, when proposed may be examined with care, and tested by means which are wanting to the originators, whereby they may be dealt with adequately.

5. To examine afresh many of the accepted axioms, aphorisms and formulæ which now pass muster for use in marine engineering, in the light provided by modern knowledge, and by methods found successful in later years, in order to prove if they have been established and still remain on sure foundations or otherwise.

6. To examine afresh the proposals and ideas contained in the old patent and other records with a view to winnowing from them the seeds of things which may now be cultivated and made to produce fruit, but which when they were first proposed, could not be done from want of the means of manufacture.

If research can accomplish these things for us, it will amply repay any reasonable sum spent on it, just as it has done in other fields where it has been properly applied, although they were far more restricted than are ours. In Cornwall to-day much wealth is being realised by examining anew the spoil banks of the old mines. From one of these pitch-blende is obtained—the source of our supply of that rare and valuable element radium. In the days when the ore was dug from the earth it was worthless from being too refractory for use, owing to the presence of this most valuable pitch-blende.

Now the scientists, philosophers, and even the engineers, who by research of a sort dug out much material in the past, have likewise left their spoil banks. We may perhaps examine them afresh with advantage as well as interest, for just as our late member Samson

Fox rescued from one spoil heap the corrugated furnace, which discovery undoubtedly benefited all of us, as well as himself, so it is quite possible that many of you may do likewise with equal advantage. It was because so many of the old patents were mere ideas only, and not really inventions, that they were never proceeded with. But contained in some of those ideas and remaining there still are the germs of what may, with due research, prove a magnificent invention. The knowledge and methods of to-day can make some of "their dry bones live" in a way that was not possible formerly. Nor could they be useful for purposes which did not then exist, whereas to-day they may be of great advantage to satisfy modern requirements.

But besides these musty grounds wherein to make research, there probably remain in engineering some unknown lands with North and South Poles for discoveries and exploration. We know little or nothing of them now, and perhaps have no better indications by which to set out on the voyages than Columbus had of the New World, at which he eventually arrived. But, after all, our ignorance of them is perhaps no more than was that at first of those who finally have succeeded in talking through a wire hundreds of miles in length, nor of those who have made it possible to transmit messages through some thousands of miles of air without any wire communication at all by the unremitting research made by them.

In the meanwhile, however, we can perhaps, with the greatest advantage, follow on the sound and practical lines adopted by Sir Alexander Kennedy with such marked success a few years ago. We can at the same time avail ourselves of the extensive installations in the physical laboratories of our colleges and technical schools to carry out many investigations, and do much useful work. Such investigations of various kinds have already been carried on in many of them with advantage, but for want of co-ordination they have not been always so productive of engineering good as they might otherwise have been.

While on this topic, it may be well to warn you not to expect too much from experiments with models of engines or of any machinery on too small a scale, for defects, which in them will be practically microscopic, may and often are in the real thing, when in use, a great and overwhelming cause of trouble. With a suitable and efficient staff and the necessary means, a school of marine engineering research should be available for practical investigations on shipboard as well as on shore, whereby shipowners could have their troubles investigated and the efficiency of their machinery tested, whenever occasion demands, in ways impossible by the ordinary engine-room staff, from want of time that can be diverted from their regular and necessary duties to that required for such work. Moreover, there is the difficulty arising from their inability by both training and temperament to act with sufficient and critical discrimination so necessary for it to be carried out thoroughly.

The work done at home in the ordinary physical laboratories can be made more useful and instructive than hitherto if directed from one sympathetic centre which can co-ordinate the results obtained, and which, when necessary, will subsidise the work. In our educational establishments there is, however, and I suppose must always be, "the daily round and common task," required not only by the educational authorities, but such as is necessary for so training the students that they may acquire proficiency in the rudiments as well as in the methods of research.

Real research does not in itself amount to much, but I venture to think that, such as it is, it might do so if directed by a special authority to ensure that the investigations are carried out in a systematic way, and that all are co-ordinated so as to afford complete evidence by which to arrive at correct conclusions. Moreover, in making these investigations the pupils will, I believe be more interested and probably learn more from them than by merely following the stereotyped courses usually followed by order of the governing authorities. Of another thing we may be pretty certain: that in these days of strenuous and unremitting work research can no longer be left in the hands of those engaged in manufacture or professional work of the ordinary kind, nor indeed are many of these best fitted by temperament and training for the patient, methodical work required for investigations. But they are, however, eminently fitted by their knowledge, experience and daily occupations to direct and control such work as is necessary for the administration, both monetary and otherwise.

That so many inventions have been made by men not of the profession nor previously engaged in engineering work, seems to me convincing proof that the class of mind best suited for research and discovery differs largely and fundamentally from that which in other men succeeds in directing successfully all kinds of work, men and other operations. Hence I suggest the differentiation indicated above. Bramah was a blacksmith and maker of locks; George Stephenson was a fireman; "Screw-propeller" Smith, the man who patented a good workable propeller and got the Archimedes built, was a farmer; Samuel Hall was in the lace trade; Goldsworthy Gurney, a doctor. The inventor who exhibited an internal-combustion engine a hundred years ago at Cambridge was a parson, as was also Ramus, the inventor of the hydroplane ship; James Watt was an optical-instrument maker; the inventor of the chronometer, and winner of the King's prize for it, was a gardener; "Increasing-pitch" Woodcroft was a librarian; Bessemer was an artist; Armstrong a lawyer; and even in our own days we have had very many valuable additions made to our knowledge by men outside the profession, which all goes to show how much more liberal we are than the members of those other professions who would monopolise that adjective for their own.

For administrative purposes, therefore, such a committee as that over which I have the honour to preside* would be a very suitable one, consisting as it does of members of every branch of the marine engineering profession, selected by the various institutions interested in marine engineering progress, and having on it also representatives of such bodies as the Board of Trade, Lloyd's Register, the Bureau Veritas, and British Corporation. To them might be added with great advantage representatives of the Admiralty, the Indian and Colonial Governments. A suitable staff with a director at its head would be also necessary, but I do not propose to deal with such details, as for the present I am chiefly concerned to win from you the acceptance of the principle that there should be some definite body to take up seriously the direction of the work of research in all marine engineering matters, and further that there shall be no longer any delay in forming such a body *ad hoc*.

Many of you no doubt are aware that an important Government Department was constituted in 1915 under the title of "The Committee of the Privy Council for Scientific and Industrial Research," and that it is assisted by an Advisory Council as well as by Standing Committees on engineering, metallurgy, mining, and other applied sciences. A fund of 1,000,000*l.* has been placed by the Government at the disposal of the Research Department to encourage British industries and to undertake research work generally, but so far, I am not aware that any of it is earmarked or otherwise reserved for any undertaking that may be considered as marine engineering, notwithstanding that the importance of this branch of industry to British and Colonial maritime interests should entitle it to a considerable share of such a grant. It appears, however, that it is proposed that certain bodies or associations in various localities representative of the local industries shall co-operate with the Council of Research, and that the cost of such research work as may be undertaken in this way shall be partly defrayed from funds subscribed locally by parties interested in the results and partly by grants from the Government Fund equal in amount to the subscriptions. In this way marine engineering may possibly come in for recognition. On the Main Advisory Council we find one of our distinguished vice-presidents, Sir Charles Parsons, and representing the Admiralty as assessor to it is another vice-president, Sir E. H. Tennyson d'Eyncourt; while on the Standing Committee on Engineering this Institution is directly represented by Sir Archibald Denny and indirectly by some of our members who represent other institutions interested in marine engineering.

We can be sure, therefore, that the interests with which this Institution is so clearly connected will not be entirely overlooked, and that to whatever use the funds thus furnished are put and whatever great opportunities are thrown open, naval architecture and marine engineering will have their fair claims for consideration fully satisfied. The Engineering Committee referred to above have furnished a list of subjects thought to be suitable for our immediate research in marine engineering. The field covered by this list is so wide and instructive as to emphasise all that I have said in support of the necessity for research in marine engineering, and I cannot do better than append it to this paper and commend it to your consideration.

APPENDIX.

SUBJECTS FOR CONSIDERATION SUGGESTED BY THE ADVISORY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH.

Marine Engineering.

1. *Marine Engines.*
   (*a*) Consumption per indicated horse-power or shaft horse-power of various types of engines.
   (*b*) Accuracy of torsion-meter experiments.
   (*c*) Efficiency of gearing of various kinds between engine and line shafting.
   (*d*) Limits of peripheral speed for gear wheels.
   (*e*) Application of roller or ball bearings to marine engines.
   (*f*) Lubrication of stern tubes.
   (*g*) Best kind and shape of nozzle for impulse turbines.
   (*h*) Superheat and its effect on cylinder materials.
   (*j*) Cylinder cooling (internal-combustion engines).
   (*k*) Further investigation as to the value of water injections.
   (*l*) Internal-combustion turbine engines.
   (*m*) Lubricating oil for high temperatures.
   (*n*) Most efficient management of condenser cooling surface and extraction of condensed water.
   (*p*) Air pump efficiency.
   (*q*) Centrifugal pump efficiency.
   (*r*) Feed heaters, efficiency of various types.
   (*s*) Best methods of preventing lubricating oils from entering boilers.

2. *Marine Boilers and Fuel.*
   (*a*) Direct coal burning on grate.
   (*b*) Atomised coal dust firing.
   (*c*) Oil fuel.
   (*d*) Oil burners for boilers.
   (*e*) Boiler tubes.
   (*f*) Transmission of heat.
   (*g*) Lagging of boilers and steam pipes.
   (*h*) Mechanical stokers.

3. *Constructional Materials.*
   (*a*) Metal for turbine blades, impulse or reaction, saturated or superheated steam.
   (*b*) Mixtures of iron for internal-combustion engine cylinders, valves, valve seats, &c.
   (*c*) Casting under pressure.
   (*d*) Gun-metal: heat-treatment of, &c.
   (*e*) Non-corroding alloys.
   (*f*) Bearing metals.

4. *Refrigerating.*
   (*a*) Methods and application.
   (*b*) Distribution of refrigerated air.
   (*c*) Insulating materials.

* The British Marine Engineering Design and Construction Committee.

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held at the Imperial College of Science and Technology on March 14, Mr. S. D. Chalmers, M.A., Vice President, in the chair.

Exhibits from the National Physical Laboratory which were demonstrated by Mr. E. M. Eden consisted of a projection apparatus for Gauge Measurement with large field of view free from distortion; and a simple method of viewing some faults in silvered plane mirrors. Dr. R. S. Clay exhibited a thin collodion film showing the phase reversal caused by silvering a portion of the surface; and a specimen of polished glass proving the flow which has occurred in pitch polishing which was rendered manifest by a subsequent cloth polishing.

A communication on "*The Detection of Ghosts in Prisms*" by Mr. T. Smith, B.A., followed. The author showed that ghosts in prisms are caused by reflexions other than those which form the principal image. Ghosts in prisms are apt to be more serious than those in lenses, inasmuch as a single additional reflexion may cause a ghost in a prism, while at least two are necessary in a lens. Moreover in lenses the ghost-producing reflexions occur at unsilvered surfaces at small angles of incidence, but in prisms the surface may be silvered or the ghost may be produced by total internal reflexion. Every possible way in which a ghost can arise in a prism may be determined by a suitable development of the prism, or of a section of the prism, on a plane. If a diagram is drawn showing all possible positions of a prism derived from a given initial position, the entire path of any ray within the prism is represented by a straight line, and the deviation of the ray is of the constant type if the ray has crossed an even number of lines representing reflecting surfaces, and of the variable type if the number is odd. Diagrams of this type have been drawn showing the sources of ghosts in a number of the best-known prisms of comparatively simple construction; they indicate what steps are necessary to avoid the presence of ghosts in a complex instrument of which the prism is a part. The principal ghosts in a number of cases have been photographed, and slides of these were shown. The ghost in many cases is as brilliant as the principal image. Further illustrations were obtained by projecting a pattern on to a screen through a number of prisms of different types.

A discussion on the paper and that by Naval Instructor T. Y. Baker, R.N., on "*Reflecting Prisms*" presented at the previous meeting followed, and a vote of thanks to the authors concluded the proceedings.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—The Industrial Reconstruction Council will hold the second of its series of important provincial meetings, at the Assembly Hall, Edinburgh, on Wednesday, April 3, at 8 p.m. The Lord Provost will preside and Dr. Addison, Minister of Reconstruction, will be the principal speaker. The object of the movement is to arouse a widespread interest in the recommendations of the Whitley Committee for the establishment of a Joint Council in every industry, and in view of the recent publication of the second report, this meeting is particularly opportune. Applications for tickets should be made to the Secretary, the Industrial Reconstruction Council, 8, Bouverie-street, E.C. 4.

GERMAN CHEMICAL WORKS IN 1916.—According to the report drawn up on behalf of the Chemical Industry Association, the increased activity of the industry during 1916 showed itself in the increase of the number of works, 14,993 (against 14,914 in 1915); in the number of full-time workers, 256,420 (an increase of 16¾ per cent over 1915); and half-time or day workers, 632,000 (against 543,000); and in other respects. The number of full-time workers was practically the same as in 1913; but it comprised many boys, girls and women, of course who had supplanted men called up. The number of accidents had also risen from 12,041 in 1915, to 14,908; of these 389 were fatal, against 299 fatal cases in 1915, and 148 in 1913. The heaviest figures in accidents were due to combustible and corrosive and hot liquids and gases, to power machinery, to lifting and carrying, and to ladders and stairways, in this descending order. Explosions caused 942 accidents, of which 206 proved fatal; power machinery was responsible for twice as many cases of injury, but not for so many fatalities. There had been an improvement in accidents in the latter half of the year, however, which is ascribed to improved ventilation, respirators, protective gloves, and general cleanliness. Belt shifting had led to a large number of the machinery accidents, and belt shifters of the fixed and loose pulley type were being withdrawn. It is pointed out that several relatively safer branches of the industry had fallen off, whilst the more dangerous branches had developed during the war; or so far, and as regards the experienced *personnel*, pre-war and war conditions were not directly comparable. As regards the number of employees, the Cologne district (comprising Elberfeld) was still leading; there followed Leipzig, Hamburg, Mannheim (with the Ludwigshafen works of the Badische Anilin-und Soda-Fabrik, on the opposite bank of the Rhine), and Berlin.